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What is in This Book

Pages 1 to 121 contain *752 Definitions* of processes, materials and pieces of equipment thoroly cross referenced.

Page 122 contains outlines of the *Association* activities.

Page 124 contains the *Departmental Index* of plant equipment, which is a comprehensive index of all related subjects.

Pages 126 to 200 contain the *Statistical Section* (*indexed on page 126*), including the most vital and essential data required in clay products manufacture.

Pages 201 to 252 contain the *Catalog* descriptions of the most important equipment and services required in the industry.

We will look up one subject to show the use of this book.

How to Use the Definition Section.

Suppose, for instance, that we are going to open a new clay pit and wish to obtain information on a haulage system. We know that a locomotive is used for this purpose and look it up in the Definition Section. We find that there are three items, 410, 411 and 412, on pages 87 and 88, devoted to different types of locomotives. Directly beneath the definitions we find a list of the names of those manufacturers who have included their catalogs in the Cyclopedia. We also find several lines of announcements of these manufacturers.

How to Use the Catalog Section.

Possibly we may want further information and learn that by turning to the catalog pages we can locate the catalog description of the locomotives made by these manufacturers, and also the addresses of the latter. We therefore write these firms, explaining our pit conditions, and asking for prices. We find it easy to locate the catalog pages because they are presented in alphabetical order.

How to Use the Statistical Section.

We still are anxious to learn more on this subject, and turn to page 126 to see if there is any information on this subject in the Statistical Section. We find that item 410 has some data on page 180 and we look that up.

Suppose that the use of a locomotive would entail great expense on account of a trestle. How can we obtain information on other transportation equipment?

How to Use the Departmental Index of Plant Equipment.

We turn to page 124 and under the heading Clay Winning we find one subhead entitled Transporting Equipment. Looking up all of the items indexed therein we find one, number 4, to be a description of an aerial tramway. We learn that this is just what we desire, but discover that we are blocked in our search for further information because there are no manufacturers' names listed under the definition.

How to Use the Preface.

We remember, however, having read in the preface that the editors offered to furnish the names of the manufacturers of any item under which no names are listed. We therefore avail ourselves of this opportunity.

Suppose that we had heard that there was such an equipment as a tramway, but did not know anything about an aerial tramway. How could we find the information?

We look up tramway and see that on page 115 there is a cross reference to aerial tramway.

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Clay Products Cyclopedia

Containing Important Information *for* Every Executive *from* President *to* Foreman

of

Every Branch *of the* Clay Products Industry Including
Both Pottery *and* Heavy Clay Products

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Preface

IN PREPARING this cyclopedia for the clay products industry, we have kept uppermost in our minds the great necessity for detailed information that is today needed and will be needed for many years to come, regarding every step that is required to change raw clay or shale into the best material in the world for the many purposes for which it is used.

We look back at this time on the past six or seven years in which there has been small demand for many lines of clay products. A study of industrial history, however, shows that business activity swings like a pendulum. On this basis, we are very safe in predicting that the curtailed business of the past few years in clay products will be reflected by abnormal demand in the years ahead. Even at this writing the unmistakable signs of returned prosperity are very evident.

It is not so much the knowledge of fundamentals as it is the intimate details of business that enables one to forge ahead of another. The industry whose personnel is best informed on all the details pertaining to the manufacture of its product is the one which will be best equipped to reduce costs, improve quality, intensify merchandising and thus outstrip competing industries.

This book has been prepared with that idea in mind—to make available for everyone in the clay products industry, be he president or foreman, the data and information that he wishes without a moment's delay.

Naturally, much of this material is copied from authoritative sources, but also much of it is original. We have taken all precautions possible to prevent errors, but some may have crept in inadvertently. For these we ask your kind indulgence, but request that you notify us of any that you discover so that they can be corrected before the next issue goes to press.

In the definition section we have listed alphabetically the processes, equipment and materials used in the industry. As far as possible the definition is listed under the noun, e. g., Dryer, humidity, and there is a cross reference Humidity dryer. In some cases one letter changes the location of an item, e. g., Drying (not dryer), how it proceeds.

The names of the firms supplying each item are included after each definition. We will supply, on request, the names of the manufacturers of any equipment under which no names are listed.

In the statistical section we have a wealth of information and instructions indexed by the same numbers as used in the definition section. There is an index for this section.

In the departmental index we have listed the information, equipment and processes applying to each department. We feel that this will prove valuable in making suggestions for improving plant conditions.

In these several sections we have striven to give all the information possible without advocating the use of any special process or favoring any firm supplying the industry. We felt, however, that our readers would desire a description of the machines and equipment made by the different firms, and to that end asked those who wished to call attention to special features in their product to use one or more pages in our catalog section.

The many catalogs needed in the plant are often easily lost. The delay in obtaining supplies, repairs or new equipment, on account of losing the catalog that especially fits the case, is often very costly. Moreover, the printing of a catalog is an expensive procedure, and many firms issue one about once in three or more years. Often improvements are made during that interval which cannot be cataloged.

Our catalog section has been established for this purpose—to supply up to date catalog knowledge showing the special features of every piece of equipment, and to keep this information bound in one compact permanent form for ready reference. The pages in the catalog section are arranged in alphabetical order.

THE EDITORS.

Chicago, Ill., March 1922.

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F. A. Guignon **A. G. Ruppert**
H. V. Kaeppel **F. L. Steinhoff**

We are Indebted to the following sources of information for most of the data that is not original:

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Various Catalogs of Firms Supplying the Clay Products Industry.

ABBREVIATIONS

a.c.	alternating current
Amer. Cer. Soc.	American Ceramic Society
Ann. Rept.	Annual Report
B.C.	Before Christ
B.t.u.	British thermal unit
Bull.	Bulletin
C.	Centigrade
C.C.	Cream-colored
c.c.	cubic centimeter
cm.	centimeter
ct.	cent
cu. ft.	cubic foot, feet
cu. yds.	cubic yards
d.c.	direct current
deg.	degrees
ed.	edition
e.g.	for example
etc.	and so forth
F. Fahr.	Fahrenheit
Fig., fig.	Figure
F.P.M.	Feet per minute
ft.	foot, feet
gal.	gallon
Geol. Surv.	Geological Survey
gr. g.	gram
h.p.	horsepower
hrs.	hours
i.e.	that is
in.	inch
ins.	inches
Inc.	Incorporated
kg. kilos	kilogram
k.w.	kilowatt
lbs.	pounds
min.	minute
mm.	millimeter
Mme.	Madame
No., no.	Number
oz.	ounce
p.	page
pub.	published
r.p.m.	revolutions per minute
sp. gr.	specific gravity
sq. in.	square inch
sq. yd.	square yard
trans.	translated
Trans.	Transactions
U. S.	United States
Vol.	Volume
wt.	weight
yd.	yard
%	per cent.
°	degree

Clay Products Cyclopedia

Definition Section

A

ABSOLUTE TEMPERATURE, see Temperature, absolute.

1—ABSORPTION.—The power of unglazed articles to absorb liquids or gases is of great importance for certain purposes, including the probable resistance to the elements and to the corrosive influences of gases, slags and various chemicals. The absorption test for clay products is made by weighing five dried pieces and completely submerging them in distilled water. The water is then brought to a boil and the ware boiled continuously for two hours and then allowed to cool in the water to room temperature. During the boiling none of the ware being tested should come into contact with the heated bottom of the container. When cooled to as near 20 deg. C. as possible in the room atmosphere, each piece should be dried lightly with a damp towel to remove the excess water and weighed in the air to an accuracy of 0.1 gram.

Absorption should be reported in terms of percentage weight of the dry sample, and should be obtained by dividing the weight of water absorbed, in grams, by the weight of the dry test piece, in grams.

2—ACCOUNTING.—This is the science of higher bookkeeping, in which in addition to the regular work of keeping the accounts in the journal, ledger, etc., the items of Depreciation, Obsolescence, Capital, Investment, Income and Cost accounting are considered. The reader is referred to each of these items and also to Auditing, Income Tax and Appraisement.

3—ADSORPTION.—This term is used to indicate the power which a clay has of removing solid substances from solutions with which it is in contact. Naturally, the degree of adsorption, as well as the substances which a clay will adsorb, vary with the nature of the clay and the conditions under which the test is conducted.

4—AERIAL TRAMWAY.—The aerial tramway is used largely to facilitate the delivery of materials—coal, shale, ashes, lumber, brick, etc.—across ravines, over railroad tracks and other obstructions, and to eliminate waste labor in carrying coal or other material from the cars to the point of storage. The simple type consists of a cable, supported at each end by a pole or steel framework, with the carrier suspended, by means of a cable or heavy rope, from a grooved pulley or trolley which travels on the cable. The more modern type generally replaces the cable with an I-beam or monorail, adequately strengthened at definite intervals by upright steel masts or poles. A hoist house is generally erected convenient to the point of loading, and all operations of loading, hoisting, conveying and discharging are controlled by an engineer stationed in the house. The modern hoist, used in conjunction with the tramway, can usually be operated by an electric motor, steam engine, gas engine or shaft drive. The ease and rapidity with which practically any class of material may be handled, combined with their labor-saving features, is resulting in the increasing use of aerial tramways. They are used on distances up to several miles.

5—AGITATOR.—Agitators are used in pottery plants. After being screened, the clay slip flows or is pumped to a rough agitator and thence thru a series of horseshoe magnets or electromagnet machines (which extract the particles of iron from the slip) into a smooth agitator. These agitators are merely large cylindrical tanks fitted with an interior revolving mechanism that keeps the slip in motion and prevents the heavier particles from slipping to the bottom, thus insuring a more uniform mixture before the slip is pumped to the filter press. This agitating mechanism consists of steel arms and wooden gates, or wooden arms only, mounted on a revolving shaft which is vertical.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
Mueller Machine Co., 21-23-25 Ward Ave., Trenton, N. J. Built with single or double paddle shaft. If equipped with double shaft is driven by planetary movement which gives paddles a very effective double motion.

6—AIR BRUSH.—Air brushes are tools or instruments for applying any liquid to a surface, for instance applying a liquid decoration to pottery, terra cotta, or a liquid paint to the walls of a building. The application is made by a spray. The brush resembles a revolver and has two hose connections, one for compressed air and the other for the liquid. The handle holds a needle valve which controls the feed. The pressure is obtained from a tank of compressed air, which is filled by an air compressor.

AIR-BRUSH DECORATING, see Decorating, air-brush.

7—AIR COMPRESSOR.—This is a machine for compression of air at pressures higher than atmospheric. They are made, in the main, very much like a pump or engine, the air being the medium that is pumped and compressed instead of water. They may be driven by engine, belt or motor. The piston or pistons reciprocate in the cylinders and valves are provided very much like those of a pump to admit the intake and outlet of the air that is being compressed. Compressors must have some method of cooling their cylinders, because air gives up heat when being compressed and if no cooling arrangement is provided, the metal cylinders will become overheated. A circulation of water is the method usually provided. Air compressors are used in air brush decoration, and compressed air provides the best means of cleaning motors, generators, alternators, and other electrical machinery from the dust that is bound to accumulate around the brushes, commutators, fields, armatures, etc. In silica brick manufacture compressed air provides the best method of cleaning the metallic pallets of the gathering or accumulation of lime deposit. Many other uses are found for compressed air but they are generally special for the plant that uses them. In some cases cranes and hoists are operated by compressed air.

8—AIR DRYING.—This refers to the ancient and modern practice of drying certain clay wares without the assistance of heat, except of such heat as is naturally contained in the air, or such as may be derived by radiation from burning and cooling kilns. (See also Dryer, relation of air to.)

DESIGNERS (see catalog section):
Freese, E. M. & Co.
International Clay Machinery Co.

8A—AIR FLOW METER.—This instrument is of the anemometer type. The flow, however, is exerted against a vane instead of against a small fan. The flow is registered on a dial, similar to a boiler gage, which can be made to read in any set of terms desired, instead of on a set of numbered dials as in the ordinary anemometers. The air flow meter is valuable in showing the variations in the flow of air or gases in a flue or duct.

9—AIR SEPARATION.—The term refers to a method of cleansing clays that is particularly applicable where it is necessary simply to remove coarse and sandy particles from the raw material. The process consists of feeding the dry clay to a pulverizer, which reduces it to a finely powdered state. As the material is discharged from the pulverizer into a long box or tunnel, it is seized immediately by a powerful air current (derived from a fan) which picks up and carries the fine particles to the end of the airway, where they are dropped into a bin. The coarser particles, too heavy to be picked up by the current, drop back and are run thru the pulverizer again. The method is especially suited to kaolins free from iron, but hardly adaptable to clays containing ferruginous particles. There are several forms of air separators on the market.

MANUFACTURER (see catalog section):
Bonnot Co.

10—ALARM, HIGH AND LOW WATER FOR BOILERS.—These attachments are used to indicate to the operator that a danger of damage exists if the height of the water in the boiler is not attended to. This is accomplished by several methods. In some there is a float which is connected by a lever to an arm outside of the boiler. This arm can connect up an electric current which rings a bell or permits steam to escape and blow a small whistle. Low water alarms, which are more important, are often made by filling a pipe with water, and immersing it in the water of the boiler. The lowest end is generally placed at the level at which it is desired to give notice to the operator if the water falls that low. As long as the water is kept at the proper level this pipe is kept full of water and no signal is made. As soon, however, as the water falls below that level the pipe is emptied of its water and steam rushes in to blow a small whistle at the top of the pipe. Many variations of these attachments are manufactured. Low water in a boiler is liable to cause the exposed tubes and sheets to become burnt and thereby rendered unfit for further service, and the joints, especially around the tubes, are liable to leak. In addition there 's more danger from explosion if cold water is fed into the boiler at too high a rate. If water is carried too high the steam may carry some water into the cylinder of the engine, where great damage may result, even to the blowing out of the cylinder head, because water is incompressible. The last portion of the exhaust stroke of an engine piston compresses the steam which has been admitted and if this steam carries too much water the cylinder head will be blown out. These alarms, therefore, afford insurance against trouble and damage. The water column of a boiler may become clogged so that the gage cocks or gage glasses will not show the true level of water thru no negligence of the operator.

ALARM, FIRE, see Fire Alarm.

11—ALKALIES.—The alkalies usually present in clays include potash (K_2O), soda (Na_2O), and ammonia (NH_3). There are other alkalies, but they are of rare occurrence. The amount of fixed alkalies that clays contain, varies from a mere trace in some to 9% in others. The minerals supplying alkalies are all silicates of complex composition. Each has its fixed melting point, and the temperature at which the alkalies flux with the clay will depend on the containing mineral, and also on the size of the grains. If the alkali-bearing mineral grains decompose, the potash or soda are set free and form soluble compounds.

Alkalies are probably the most powerful fluxing material that clay contains, and, when present in the form of silicates, constitute a desirable constituent, except in clays of a refractory character. Because of their fluxing properties, the alkalies serve, in burning, to bind the particles of the clay mass together in a dense, hard body, and permit a white ware, made of porous-burning clays, to be burned at a lower temperature.

Alkalies alone seem to exert little, if any, coloring influence on the burned clay, altho in some instances potash appears to deepen the color of a ferruginous clay in burning.

12—ALLOPHANE.—A mineral, amorphous in nature; related to kaolinite; appears as incrustations in the clay mass, being usually thin, with mammillary surface. Allophane is occasionally almost pulverulent; fracture imperfectly conchoidal and shining to earthy. Very brittle. Color, variable. Translucent. Hardness, 3. Sp. gr., 1.85-1.89. It is a hydrous aluminum silicate: $Al_2SiO_5+5H_2O$=silica 23.8, alumina 40.5, water 35.7.

ALTERNATOR, see Generator and alternator.

13—ALUNDUM.—An artificial emery made from bauxite in an electric furnace. Alundum melts at 2,300 deg. C. (4,660 deg. F.). Fused alundum has a low coefficient of expansion and contraction, is inert chemically and very little affected by slags. Its high cost prevents its general use, but large quantities of alundum crucibles, combustion tubes and muffles are employed with considerable success.

14—ANEMOMETERS.—These are instruments for measuring the velocity or volume of air, passing a certain point. They consist of a small fan-like wheel that revolves very easily when there is a current of air passing thru it. The number of revolutions of the wheel is recorded on a set of dials which are easily reset to zero. The dials are graduated to show the volume of air in proportion to the diameter of the wheel, that is, the dials are graduated differently for a two inch and a two and a half inch wheel. These instruments are very serviceable for measuring the volume of air passing thru a dryer or flue, or the velocity at the same point. A convenient clutch for starting and stopping the instrument is provided so that it can be operated exactly for any period of time desired. Knowing the volume and velocity of air thru a dryer is valuable for efficient regulation. (See also Air flow meter.)

15—ANTI-FRICTION METAL.—Generally, any alloy of metals used in the manufacture of bearings or bearing linings, to reduce the friction between moving bodies. Copper, tin, lead, antimony and zinc form the basis of the varied compositions of which anti-friction metals are composed. Babbitt and bronze are typical products. Thru special processes of manufacture, the quality of anti-friction metals varies greatly, with each manufacturer claiming certain distinctive properties for his own products that particularly fit them for special operating conditions. (See also Bearings, ordinary types of.)

16—APPRAISEMENT. — Appraisement is the operation of determining the value of a plant after it has been built and in operation. Several methods or bases are in common use, one being the original cost, and another the cost of replacement at present prices. Of course, in every case depreciation and obsolescence are taken into account. Appraisement is really a detailed audit of the capital, depreciation and obsolescence accounts. In the regular audit of the books of account the value of the investment in plant and equipment, and the depreciation and obsolescence allowed therefor are not considered in as much detail as in appraisement. Appraisement not only determines whether or not the plant and equipment is worth more or less than the full value paid therefor but also determines whether or not the rate of depreciation and obsolescence has been correct. (See also Income tax.)

APRON FEEDER, see Feeder and mixer, clay.

17—ARCHITECTURAL PORCELAIN.—The Chinese used porcelain for architectural decoration and even in the construction of walls as long ago as 945 A. D., tho this material, on account of its great shrinkage and cost, is not suitable for making thick articles. Also, the extreme hardness and translucency which make porcelain so highly acceptable for tableware, have little importance in monumental pottery.

17A—ARGILLACEOUS.—This term refers to the clayey or plastic material found in the surface of the earth. It is used chiefly in contrast with or in distinction from siliceous.

18—ARK.—A term used to designate the tank into which a pottery mixture is run from a blunger. Since stones are removed from the clay before it is put into the blunger, either by a previous washing or by grinding, the clay which is put into the ark is homogeneous.

19—ASBESTOS.—A light, extremely fire-resistant compound; chemically, a hydrous silicate of magnesia—i.e., a compound of water, silica, and magnesia. It is woven into sheets which possess little binding strength. Since it is very serviceable for gaskets for internal combustion engines and in similar places, brass wire is interwoven with the asbestos to prevent the fibers of asbestos from being separated and the packing being destroyed. Asbestos is also largely used as part of the woven gaskets for boiler manholes, hand-holes, etc. Asbestos in itself is not as good for steam pipe covering as some other materials, but on account of its lightness and the fact that it holds air between its fibers, it is largely used for that purpose, both as a prepared molded covering and as a cementing paste. The molded pieces are used for the straight pipe and the plastic cement for the pipe fittings and irregular and inconvenient places.

20—ASH-HANDLING EQUIPMENT.—Since the amount of coal used in a clay products plant for power and burning amounts to approximately 30% of the tonnage of the output of the plant it is evident that the economical handling of ashes is an important item. In the boiler room they are often hauled from the ash pits by wheelbarrows and dumped outside to be picked up later by cart, wagon or auto truck. In up-to-date boiler plants and especially where stokers have been installed, some mechanical means are usually provided for removing the ashes. These may take the form of drag, chain, flight, apron, pan or belt conveyors. In some cases these conveyors run under the ash pit and in other cases they run under the floor of the boiler room. There is likewise a screw conveyor type which can be operated in either place. In some cases the ashes are loaded in a bucket which operates on a rail and is dumped outside. If a large supply of water is available a stream can be made to run under the ash pit and the ashes washed off in this. There is also the vacuum conveyor in which a suction of air creates a vacuum in a tank and the ashes are fed into a pipe connected with this tank. There is also another type, namely, the steam jet conveyor, in which the ashes are moved along a conveyor pipe by means of the force exerted by a jet of steam. Any of these types can be built to take care of the ashes around a kiln, but since continuous kilns produce small amounts of ashes and the installation costs a great deal for intermittent kilns, very few installations are found. In most intermittent kilns the ashes are thrown out of the fire box by hand and gathered into a pile from which they are hauled by a cart, wagon or auto truck to a dumping place. The auto truck has been found very satisfactory and economical for this purpose. For loading the ashes into the carts, wagons or auto trucks, whether from the pile outside of the boiler room or at the kilns, one of the portable belt loaders described under Conveyor, portable is most satisfactory.

All gas producers should be equipped with a good ash removing system, and this will consist of an elevator in most instances. Irrespective of where the ashes are produced or dumped they can be gathered and loaded into a car if desirable by using a bin in connection with any of the systems described.

MANUFACTURERS (see catalog section):
Green, L. P.
International Clay Machinery Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

21—ASSAY SLAGS.—These slags are used to test the suitability of crucibles made of clay (see Crucible manufacture) which are designed for the assaying of various ores. Assay slags are empirical mixes of strong fluxes which are designed to fuse easily and quickly themselves and also to dissolve the ore which is mixed with them in the charge. In effect, the assay slag is a fiery solvent which dissolves the ore into a thin, watery silicate, and in that condition applies the reagent needed for the separation of the metal involved. The compositions of two typical slags are given. (1) Litharge, 2 parts; bicarbonate of soda, 1 part. (2) Carbonate of potash, 4 parts; bicarbonate of soda, 4 parts; borax glass, 2 parts; argols, 1 part; ferric oxide, 2 parts. No. 1 has been found much superior in corrosive power to No. 2.

22—AUDITING.—Auditing is the checking up for correction of invoices, sales, purchases, and other entries in the books of account. It is closely allied with accounting. Almost all of the larger companies have their accounts audited once a year or oftener. It serves as a check on the profits for the year, and is valuable also in these days of income tax returns.

23—AUGER, BRICK AND HOLLOW-WARE.—An auger consists of a cylindrical shaft equipped with a powerful screw-wing, which, as it revolves, forces the plastic clay in the pug-mill or auger machine out thru the molding die, modeling the plastic mass into the form of brick, hollow tile, hollow block, etc. (For details of operation, see several entries under Die.)

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.

AUGER, HAND FOR DRILLING CLAY, see Drill, hand auger.

24—AUGER MACHINES.—An auger machine is that type of machine in which the clay is forced out of the die by means of the revolution of an "auger," which is a continuous screw, made somewhat like a sausage machine or grinder. In the manufacture of stiff-mud ware the auger machine is the type most commonly used, as larger output is produced at a minimum cost. In the manufacture of brick of all kinds, drain tile, hollow building tile, silo blocks, conduit, etc., the auger machine is especially suited unless the clay is of a tender nature or the ware should be too dense. The clay chamber is often lined with renewable plates so that as the augers wear, both liners and auger can be renewed. These machines are made for both vertical and horizontal delivery, and in some types of horizontal delivery part of the clay chamber is vertical. The die forms an important feature in the use of an auger machine, as a poorly constructed die will spoil a large part of the output. (See Stiff-mud brick machinery; and the several items under Die.)

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Steele, J. C. & Sons.
Stevenson Co.

MANUFACTURERS' ANNOUNCEMENTS:

Bonnot Co., Canton, Ohio. Complete line of auger machines for all capacities, both brick and hollow ware.

Freese & Co., E. M., Galion, Ohio. Union brick and tile machine—an auger machine and a pug-mill in one construction, operated on one set of gears driven by one belt.

Forced auger feed—arrangement of wide-faced feeder arms working into and between the spirals of the auger of a brick or hollow ware machine to give a positive feed into the auger and prevent bridging of the clay.

International Clay Machinery Company, Dayton, Ohio, have in recent years brought out a new design in auger machines, the entire base being cast in one piece. This, in addition to resulting in a machine of great strength simplifies repairs as all bearings, being an integral part of the frame, cannot be disturbed. Other advanced details such as two thrusts on the auger shafts, all ring or chain oiled bearings, removable liners, a balanced clutch with one point adjustment have been used, resulting in machines which are a great advance in auger machine design. See our pages in catalog section.

AUTOMATIC ROTARY CUTTER, see Cutter, and cutting table, rotary, all types.

AUTOMATIC SOFT MUD BRICK DUMPING ATTACHMENT, see Soft mud brick automatic dumping attachment.

AUTOMATIC STOVEROOM, see Stoveroom, automatic.

AUTOMATIC TRIPPER, see Conveyor, automatic trippers for.

25—AUTOMOBILE TRUCKS.—Automobile trucks are conveyances driven by electrical storage batteries or internal combustion engines, for transporting material from place to place. They have replaced horse-drawn wagons and carts for many uses around clay products plants. They are built in many cases with side or end dump bodies. Where the deposit of clay is located at some distance from the plant, automobile trucks are often found hauling the clay economically. At the plant a truck is found to be very efficient transporting coal and ashes. In addition, companies that deliver part or all of their product for local use find truck delivery to be ideal. (See also Truck dump bodies.)

B

26—BABBITT METAL.—A soft, white anti-friction metal of varying composition; e. g., 4 parts of copper, 8 parts of antimony and 24 to 96 of tin. The larger the proportion of tin, the harder the metal. Babbitt metal is the most commonly used lining for shaft bearing boxes of all sizes. This is due primarily to its cheapness and to the ease with which a bearing may be relined.

In rebabbitting a box the shaft is supported accurately in place, and the ends of the bearing plugged with clay or putty to prevent any molten babbitt from escaping. The babbitt is heated, preferably in a portable forge near the work, until it will set fire to any stick of wood that is put into it for trial. The babbitt is then ready to pour into the space between the bearing and the shaft. In a split box the bottom is always poured first and the same procedure followed for the cap of the bearing, except that special provision must be made for oil holes and grooves, so that the lubricant can get in between the shaft and the babbitt, in order to lubricate the bearing.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Toronto Foundry & Machine Co.

27—BAFFLE.—Baffles are thin plates of metal (sometimes wood) used in brick and hollowware auger-machines to regulate the flow of the clay column thru the die (for description and methods of using, see Die, factors of operation).

The fire clay brick, that are used in boilers of almost all types except the plain return tubular boiler, to direct and lead the gases of combustion around the flues so that the full benefit of the heat will be obtained, are also called baffles.

28—BAG-WALLS.—A bag-wall is a small addition of brickwork which is built within the kiln to prevent direct contact between the fire gases and the ware to be burned. There are many types of bag-walls, round and square, high and low. The high bag-wall is best suited (1) to protect the ware from flashing, (2) to throw the heat more to the center of the kiln, and (3) to prevent the ware from being drawn into the fire boxes or to prevent melting. In brick kilns, where the setting is run up tight against the bags, the semi-circular bag-wall offers greater resistance to crushing and to the pull of the fires than the rectangular type, and is, furthermore, more economical of floor space. The area and height of the bag-walls should be built to suit the fuel that is being used and the ware that is being produced.

BALATA, see Belting, rubber and composition.

29—BALL BEARING.—Ball bearings refer to the system of lubrication in which the shaft or axle is surrounded by balls of hard steel. These balls make a snug fit between the axle or shaft and the hub or main casting of the bearing. When the axle or shaft turns, the balls roll. This requires much less power than when the axle or shaft turns in the plain babbitted bearing. The balls and the space between the axle or shaft and the hub or main casting are generally packed and filled with graphite, or a similar lubricant. The balls in each bearing must be uniform in size. Ball bearings are suited to almost any load as they can be made as large as desired. (See also Roller bearing.)

MANUFACTURER (see catalog section):
International Clay Machinery Co.

BALL CLAY, see Clay.

30—BALL MILL.—Ball mills are used chiefly in the pottery industry in the preparation of clays, where fine grinding and intimate mixture of ingredients is especially important. In general, a ball mill consists of a hollow cylinder that rotates on an horizontal axis, the clay to be ground being admitted to the revolving cylinder at one side or end. The cylinder is charged with balls of various sizes which fill about one-third its volume. The lining of the cylinder is usually porcelain. It is usually essential that the clay be kept as free from iron as possible, hence porcelain balls or water-worn Iceland flint pebbles are used. The clay and other material is broken up and pulverized by abrasion or the rubbing friction between these balls as they are caused to move upon each other by the rotation of the cylinder.

Iron or steel balls are used in some mills, when the small addition of iron to the clay will not decrease its quality.

Ball mills may be separated into two general types, intermittent and continuous.

Intermittent ball mills are those into which the clay charge is placed and ground until the requisite degree of fineness has been attained, at which point the material is removed and another charge put in.

Continuous ball mills are so arranged that the raw ingredients are fed in at one end of the rotating cylinder and gradually work their way toward the other end, becoming finer and finer until they are sufficiently pulverized and discharged at the opposite end of the drum.

MANUFACTURERS (see catalog section):
Baird Machine & Mfg. Co.
Bonnot Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Stevenson Co.

31 — BARIUM CARBONATE.—Many good clay deposits, otherwise admirably adapted for the manufacture of brick, tile, terra cotta, etc., contain impurities which cause a white scum or efflorescence to appear on the face of the fired products. The trouble usually originates thru the presence of soluble salts, such as sulphates of magnesium or calcium, contained within the clay itself, but may also be traced to salts in the water. To prevent the formation of this objectionable scum, which mars the appearance of the finished product and therefore reduces its commercial value, barium carbonate is used.

According to Gerlach, a clay containing 0.1% sulphate of lime, which is the same as four grains per pound, would need 0.6% of a gram of barium carbonate per pound of clay. This is equivalent to about 100 lbs. for each 1,000 brick, based on the supposition that a green brick weighs seven lbs. If barium carbonate costs, say, three cents a pound, $3 worth would be required to treat 1,000 brick.

The impurities in the clay or clay and water may vary decidedly, however, and the beginner must necessarily experiment to ascertain the amount of barium carbonate needed to eliminate them. The most satisfactory method is to analyze the clay and water, but where this is inconvenient, or where practical tests are preferred, good results may usually be obtained by conducting the following experiments:

From clay prepared in the usual manner, weigh out a sufficient quantity to be used for experimental purposes. Divide this into several lots—say, six. Add barium carbonate to the first lot in proportion, say, of ½ oz. to 28 lbs. of clay, and double the amount of barium carbonate in each successive lot. Fire these lots in the regular manner, taking care that each lot is properly marked for identification. From the appearance of the resultant samples, as taken from the kiln, it is usually possible to determine which mixture will produce the best results; but as efflorescence frequently develops later, it is advisable to extend the tests under the regular weathering conditions. Since, in drying molded-clay products, the evaporation is greatest from the edges and corners of the ware, the incrustations may be heaviest at these points, but the more rapidly the water is evaporated the less will be the quantity of soluble salts deposited on the surface. Incrustations which appear during drying are found most commonly on brick made from very plastic clays, which, owing to their density, do not allow the water to evaporate quickly.

As barium carbonate is insoluble in water, in order to make it thoroly and uniformly effective it should be used only in a finely powdered and precipitated condition and distributed thru the clay as thoroly as possible, because it will act only when it comes in immediate contact with the soluble sulphates. A good general rule is to add the barium carbonate immediately before or during the last thoro clay mixing operation before being worked into the finished shape. It is also generally advisable to use a trifle more barium than is actually required.

32—BARROW AND TRUCK, HAND-POWER.—The original method of moving brick or other clay products both in the unburned and burned state was by means of wheelbarrows. This method is still in existence in many places. The old style barrow with one wheel has been replaced in many cases by the two-wheeled barrow or the two-wheeled truck. The bed on the latter is flat on top, and thereby differs from the wheelbarrow. Unless the capacity is large, or the distance long it is hard to find an improvement on the use of wheelbarrows. (See also Wheelbarrow.)

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Freese, E. M. & Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

32A—BARROW, SEWER PIPE.—The essential part of a sewer pipe truck is an arrangement of arms that will fit beneath the board holding the pipe, and levers for raising this board or pallet while loaded and sustaining this load while the truck moves from the press to the drying floor and again from the drying floor to the kiln. The barrow or truck has two large wheels fitted on the end of a bent axle so arranged that the wheels are located on the sides of the pipe.

View of Sewer Pipe Barrow on the Way to Kiln.

MANUFACTURER (see catalog section):
Stevenson Co.

33—BARYTA.—The oxide of Barium BaO, used in manufacture of porcelain, pottery and chinaware.

33A—BARYTES.—Barium sulphate ($BaSO_4$), which does not contain any water, altho a related compound may be prepared which does contain water. This compound was used by Wedgewood in the manufacture of Basalt ware, in place of cornish stone. It is rarely used to-day in body mixtures.

The term "barytes," is often incorrectly applied to the mineral "witherite" which is the carbonate of barium. This error should be avoided.

34—BATHTUB AND WASHTUB.—Commonly made from buff-burning clays (such as terra cotta is derived from), and covered with both a white slip and a glaze. The lining is usually vitrified, but not the body; hence, the term "porcelain lined." The pressing, drying and burning of such a large object as a bathtub necessarily take much care and time. The pressing is done by hand in plaster molds, and the wares are commonly burned at cones nine to ten, perhaps slightly higher. A finished bathtub may weigh 500 to 800 lbs., depending on its size and shape.

35—BATTERY CHARGER.—This consists of an arrangement or mechanism for storing electrical energy in storage batteries. Batteries must be charged with direct current, and for this purpose a mercury arc rectifier is placed in the line, in fact the rectifier, with the transformer, switches, etc., constitutes the entire equipment. The number of cells in the battery must be arranged so that the voltage required by each cell multiplied by the number of cells will equal the current available. The mercury arc rectifier changes the alternating current which is supplied in most localities to direct current.

36—BATTERY, STORAGE.—Storage batteries are the source of power for driving electric trucks, both of the automobile and industrial type, and are used for some electric transfers and electric locomotives, or electric "mules" as they are called. These batteries consist of plates of different metals immersed in a solution of distilled water and sulphuric acid. The chemical action causes an electric current to be generated. These can be recharged after use, by passing a current in the opposite direction, which reverses or nullifies the chemical action which has taken place. Batteries are really devices for changing chemical energy into electrical energy.

37—BAUXITE.—A ferruginous hydrate of alumina, Al_2O_3, $3H_2O$. It is named after a town in France where it was first discovered. It is brown, yellow or red depending on the amount of iron that it contains. The chemical composition varies, but all contain a remarkably large proportion of alumina, with a relatively small proportion of silica, iron and other metallic oxides. Bauxite has been found that has 76% of alumina, 18% of silica, and 6% of fluxes. Bauxite is used in the production of alumina, aluminum, alum and for lining of furnaces that require a high grade refractory with the additional capacity of having a basic composition, that is, a chemical composition that is acted upon by certain fluxes and chemicals very slowly. Arkansas and Georgia afford the principal sources of bauxite in this country. Bauxite has very little bonding power and in the manufacture of brick about 25% of fire clay or up to 2% of lime or sodium silicate is thoroly mixed with the calcined bauxite, so that the resultant brick will withstand a crushing strength of 10,000 lbs. per sq. in. A brick nine inches by four and one-half inches by two and one-half inches weighs about seven and one-half pounds. Bauxite is not wholly proof against bismuth, antimony or lead slags.

BEARING, BALL AND ROLLER, see Ball bearing and Roller bearing.

38—BEARING, OIL-LESS.—An oil-less bearing is a bearing made from special hard wood which has been soaked in and permeated by graphite, mineral oil or a similar lubricant. It is used at times with elevators, conveyors, etc., and on several classes of high-speed machines, which operate under a light-load stress. It is very satisfactory for this kind of work, but will not stand up under heavy loads.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Weller Manufacturing Co.

39—BEARING, ORDINARY TYPES OF.—A bearing is a device or arrangement which keeps a shaft or axle in place, and permits it to be operated at any desired rate of speed, whether the shaft be operated in a horizontal or vertical position or at an angle. A bearing generally consists of a casting or castings which are made large enough to allow babbitt or other so-called frictionless metal to be placed in contact with the shaft or axle. Provision must, of course, be made for lubrication between the bearing metal and the shaft. Mineral oil, or a mixture of oil and graphite, or a well-compounded grease are the common lubricants for this purpose. In some bearings, the oil is fed thru a porous material, one part of which touches the revolving shaft or axle, the other part being in touch with an oil reservoir. Still another type, frequently used on motors, generators, and other high speed machines, has an oil reservoir beneath the bearing and a metal ring at each end of the bearing, so that, as the shaft rotates, these rings revolve in the reservoir and keep the shaft supplied with the lubricant. (See also Babbitt metal; Ball bearing; Roller bearing.)

A marine bearing is a special bearing designed to enable the shaft to accept an unusual thrust or working stress. For example, where the shaft, instead of being of uniform diameter, has a number of rings cast integral with the shaft, yet of larger diameter. Between these rings the diameter is uniform with the remainder of the shaft. A special bearing is made to fit around and between these rings. This prevents the shaft moving endwise in the bearing, and helps to take the end thrusts encountered in such operations as that met with in pug mills, auger machines, pulverizers, mixers, etc. This is of great benefit on auger shafts as the augers can be kept at the same relative position to the die.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Easton Car & Construction Co.
Freese, E. M. & Co.
International Clay Machinery Co.
Link-Belt Company.
Weller Manufacturing Co.

BED-PLATE, see Pan, dry and Pan, wet.

40—BELLEEK.—Sometimes termed egg-shell ware; a porcelain product of unusual thinness and delicacy.

BELT CONVEYOR, see Conveyor, belt, and other conveyor classifications.

41—BELT DRESSING.—A preparation for increasing the efficiency of belts. It does this in two ways, first by reducing the amount of slippage between pulley and belt, and second by going into the pores of the belt, preserving it and increasing its life. Belt dressing comes in liquid or solid form, the solid form usually being made up into a stick which can be held against the belt. The friction of the belt takes up the dressing evenly. In using any belt dressing a small amount will do better than a large amount if spread uniformly. A large amount in one place will form a cake which does more harm than no dressing at all. Each kind of belting, leather, rubber and woven canvas has dressing made to suit its special requirements and only the type suited to the belt should be used. See Belting, fabric, leather, rubber, etc. (See also formulas in Statistical Section.)

MANUFACTURERS (see catalog section):
Gandy Belting Co.
U. S. Rubber Co.

42—BELT FASTENERS.—Some belts are made endless to suit the conditions of one installation. These do not require fasteners. All other belts, however, require some kind of a fastener to make the belt drive the same as an endless belt, with the additional advantage that the belt can be shortened when it stretches so much that it slips, or loses power. (See also Belt hooks and rivets, and Belt lacing, all types.)

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

43—BELT HOOKS AND RIVETS.—In fastening two ends of a belt together, metal plates have been found to be very satisfactory in many plants. One type of these consists of hooks and plate all in one piece. The hooks are made at right angles to the plate proper and driven into the belt and clinched. When put in properly they are very strong and last as long as the belt. Another equally strong and satisfactory type has rivets which are driven thru the belt and clinched. The plate in this type is slightly curved but has no hooks. Holes are provided for the rivets and the plate is placed on the outside of the belt, between it and the heads of the rivets.

44—BELT IDLER.—A belt idler consists of a revolving wheel or pulley usually mounted on a horizontal shaft which, in turn, is supported by two steel or wooden arms or by a flexible framework of wood or steel. The device is generally stationed about midway between the two main pulleys and so arranged that the weight of the idler-pulley (which may be raised or lowered at will) rests upon the top of the traveling belt, thus causing the idler to take up the slack and assist the belt to cling to the working surfaces of the power-transmitting pulleys. The use of a belt idler is advisable when the distance between pulleys is so small that it is difficult or injurious to the belt to tighten the belt sufficiently to make it transmit the power without slipping. (See also Conveyor, idler.)

MANUFACTURERS (see catalog section):
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

45—BELTING, FABRIC.—Fabric belting is that type of belting which is manufactured from woven canvas or duck. The fabric is folded so as to make several thicknesses or "plies," and then stitching is run lengthwise and sometimes crosswise to make the belt pull as one thickness. The finished belt is dipped into a liquid preservative, which adds to the life of the belt, and counteracts acids, water, steam, heat, etc. In some makes the fabric is dipped into the preservative before being folded. Also in some cases, a thin layer of a rubber-like material is placed between the layers Fabric belting is suited to practically any of the drives around a clay products plant altho in some cases the load may be so heavy that its use will not be satisfactory unless great care is used to install a heavy enough ply to insure a minimum of stretch. It is also used as conveying apparatus in the form of belt conveyors.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Gandy Belting Co.
International Clay Machinery Co.
U. S. Rubber Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

The Gandy Belting Company, Baltimore, Maryland. Gandy, the original stitched cotton duck belting is particularly adapted to the service requirements of the brick and clay industry. Its long wearing qualities, ability to resist heat, moisture and steam, freedom from stretch troubles, tough resistance to the action of grit and abrasives, and its practical efficiency on either driving, conveying or elevating installation, makes it most economical as well as most satisfactory, efficient, and lasting. For unusual installations, where there is extremely high temperature or acids in contact with the installation Thermo-Gandy, the high temperature, impregnated black belt gives superior service. Gandy Belts all carry three distinguishing marks—the Gandy name, the special Gandy trademark, and the Green Edge.

46—BELTING, LEATHER.—As the name indicates leather belting is made from leather. Only the best parts of the hide can be used for the larger belts and where the service is severe. The several hides are lapped and the ends cut in gradually diminishing thickness. Very strong glue is used to fasten these ends together. Most large drive belts of leather are made endless, by tightening the belt all possible, cutting the belt for a lap joint, the same as if being manufactured in the factory and glueing the ends together. If the belt is made of the right kind of leather there can be no stretch. Leather belting is suited to be used in any of the drives around a clay products plant, but its use is usually restricted to main drive belts and drive belts in a machine shop. Its resistance to stretch is the quality that recommends it for these uses.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
Weller Manufacturing Co.

47—BELTING, RUBBER AND COMPOSITION.—All rubber or composition belts are made with the rubber or composition on the surface and interspersed between the layers of the fabric or canvas. The fabric or canvas holds the rubber or composition together and takes care of part of the load or pull. These belts are suited to any of the drives around a clay products plant, and especially to conveyors, as a special coating of rubber or composition is placed on the top to withstand the wear of the conveyed material. Rubber belts should be of large ply unless provision is made for taking up the stretch shortly after a new belt is installed.

One of the composition materials used for this purpose is balata, which is imported.

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
New York Belting & Packing Co.
U. S. Rubber Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

Blue Streak Belts made by Goodyear Tire and Rubber Co., are friction surface belts with a very high co-efficient of friction. They hold the pulleys sliplessly, in spite of dust. They are impervious to moisture or dampness, and subject to a minimum of stretch. They are very pliable, making the most of pulley contact, and have great strength. Thruout the brick and clay industry, Goodyear Blue Streak Belts are known for efficiency, economy, and good wear.

New York Belting and Packing Co., 91 Chambers St., New York, N. Y. Rubber belting for conveying purposes and for the transmission of power in brick and clay plants, is particularly well adapted to this service on account of its waterproof, wear resisting and non-streching qualities. By the nature of the materials used in construction of these belts—cotton duck and rubber—they resist moisture to a marked degree. The "friction" strength, or holding power between the plies of duck is so strong that the most severe usage will not cause separation. The cotton duck used in Conveyor Belts is protected against the cutting effects of materials carried by a tough rubber cover. The pulley side of the belt is also protected by a rubber cover, usually made of a lighter gage than the cover on the carrying side of the belt.

48—BELT LACING, ALL TYPES OF.—There are several types of belt fasteners (in addition to those described under Belt hooks and rivets). The original belt lace was made of rawhide and many plants still use it, satisfactorily. Some plants use an all wire lace, especially for the smaller drives. There is another type which possesses many advantages. Each end of the belt has pairs of hooks driven into it, on both the inside and outside. After these hooks are clinched, each resembles a U with about three-eighths in. between the end of the belt and the inside of the curved part of the U. The two ends of the belt are then interlocked, and a pin of metal or rawhide, of the same length as the belt is wide, is run thru the interlocked U's. This type is satisfactory and possesses the additional advantage that the belt can be taken out of use and put into use by removing and replacing the pin. (See also Belt hooks and rivets; and Belt fasteners.)

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

49—BELTS, SILENT-CHAIN.—The silent-chain belt consists fundamentally of a series of leaves or plates, the joints of which consist of segmental case-hardened liners or bushings, and case-hardened steel pins. The holes in the heads of the links are of a form which provides a lock grip for their own bushings, and a clearance space for the bushings of adjacent pitches. In operation, the improved silent-chain belt may be compared to a flexible rack, designed so as to keep automatically in proper pitch contact with the sprockets. It has a certain amount of elasticity due to the arch shaped links, and, thus, to a greater or less extent, is driving thru an elastic medium without shock or noise, which makes it very desirable for general power transmission purposes. It engages the sprocket wheels over large areas of their circumference, and in addition, it eliminates the sliding contact, such as exists between the teeth of gearing. Under average conditions the silent-chain belt permits unusually short center distances between drives. The efficiency of the silent-chain belt is rated at 98.5 to 99%. Many advantages are found for this type of belt; it can be run at high or low speeds, is not affected by heat, cold or moisture, friction of shafts is reduced, there is no slippage, it works equally well for short or long centers, and for drive at any angle. It can be run thru a bath of oil at its lowest point to lubricate the points of contact.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Weller Manufacturing Co.

50—BELT STRETCHER AND TIGHTENER.—A tool designed to pull a belt tight by removing all slack. This is done whenever a new belt is installed, or whenever a belt which has been in use has stretched so much that it slips on the pulleys and thereby does not transmit its full quota of power. A clamp is fastened on each end of the belt or at two places near where it is intended to cut it. The clamps extend beyond the edges of the belt so that two long bolts with right and left screws can be fastened to them thru holes. The bolts are then turned with a wrench and the two clamps are pulled towards one another by means of the right and left screws. When the proper amount of slack has been taken out the belt fasteners are attached and the belt stretchers removed. Instead of having the two tightening bolts working independently, some of the belt tighteners are made with a lever which acts thru a set of gears to tighten each bolt at the same time and an equal amount. Of course this is better in every way.

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

51—BELT TROUBLES, REMEDIES FOR.—The amount of money clayworkers lose thru shutdowns to take up belts, repair broken lacings and thru "slipping," is appalling; and in practically every instance these troubles can be traced to low-grade belts, or belts too light for the service. The trouble is always at its worst during a rainy spell, when the belts draw up or shrink, and tear out at the lacing. When the air drys they stretch and require taking up. The best of belts will stretch or occasionally tear out a lacing, but invariably they give sufficient warning to allow repairs to be made out of operating hours.

Machines are often equipped with belts that are too light (having too few plies) or too narrow. Contact between belt and pulley is the all-important factor in a belt drive; the greater the contact the better the drive. Naturally, drives should be arranged so that the tight side of the belt is on the bottom. This gives a greater arc of contact and eliminates the necessity of keeping the belt too tight. This in turn eliminates stretching and torn joints. When the drive is wrong—with the tight side on top—at least two plies should be added to the thickness, over and above what the tables call for.

Belts should not be allowed to run until they slip, but as soon as they show signs of being loose, should be taken up. A failing joint should be repaired as quickly as the plant shuts down.

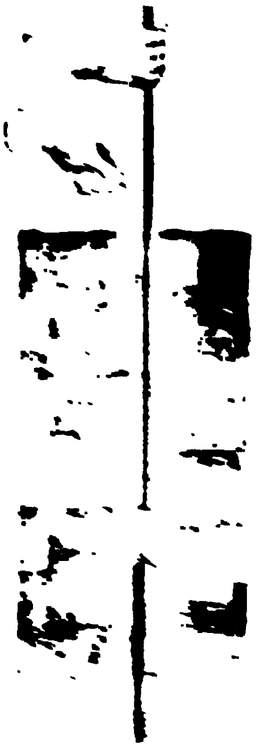
Many plants are prevented from getting "capacity" thru belt troubles alone; re-equipping with the best and most suitable belts for each specific operation would, in these cases, pay exceedingly well.

BISCUIT KILNS, see Kiln, biscuit and glost.

52—BLACK CORING.—In burning brick made from clay that contains carbonaceous matter, the ware may come from the kiln having the desired color in all portions except its center or core, which remains black. This is called black coring, and is caused by a deficiency in the amount of air that is supplied to a kiln at the time that the ware is at a dull red heat. If this deficiency exists the iron may be reduced instead of being oxidized and may also vitrify to such an extent on the surface, that later in the burning when a higher heat is attained and more air supplied the carbon in the center of the ware may combine with the oxygen to form gases, which, in trying to escape, may bloat the ware and render it unfit for use. This is not as liable to happen with a sandy clay or shale or with a fire clay as it is with a close burning clay. (See also Carbonaceous matter, and Burning, oxidation period of.)

53—BLASTING.—The operation of loosening clay, shale or earth that is to be removed as overburden or that is to be dug and used for the manufacture of clay products, by explosives. The materials and methods used are described under the items devoted to the two kinds of explosives generally used; namely, Dynamite and Powder, blasting, and the reader is referred to these items.

34—BLASTING TOOLS.—If the clay to be blasted is soft, a hard auger, which consists of a large bit similar to that used in boring wood with a handle at the top by means of which it can be turned, will be found to be the most satisfactory and fastest. This type of instrument cleans the hole as it is pulled out. When hard clay, shale or [illegible]



Tamping Bar Placing Cartridge in Hole.

[illegible]

[illegible] see [illegible]

[illegible]—[illegible]

MANUFACTURERS see catalog section [illegible]

[illegible] Clay Machinery Co.

[illegible]—[illegible]

[illegible]—The first and most [illegible]

[illegible] that its capacity is generally rated at about [illegible] lbs. of dry materials. Single blungers have half that capacity.

MANUFACTURERS (see catalog section [illegible])

International Clay Machinery Co.
Mueller Machine Co. Inc.
Mueller Machine Co. Inc. 21-23-25 Ward Ave. Trenton, N. J. Of the well-known planetary movement. Mixes clay thoroly in shortest time, using a very small amount of power. Machine with [illegible] capacity of a [illegible] lb. charge, uses [illegible] h. p.

BODY, TRUCK, DUMP AND DEMOUNTABLE, see Truck dump bodies.

37—BOILER.—A boiler is a water-tight container of steel in which steam is generated by burning fuel in a [illegible] constructed furnace underneath. Naturally there are many types of boilers made, depending on the use to which they are to be put. Around the clay plant the portable type is used, but the stationary type is used [illegible] power to drive the machinery. There are also vertical, [illegible] boilers, tubular and water tube boilers, marine, locomotive and [illegible] boilers and other designs [illegible] types.

BOILER ALARMS, HIGH AND LOW WATER, see [illegible]

38—BOILER COMPOUND.—Boiler compounds are chemicals designed to [illegible] the scale or sediment that [illegible] boiler during operation. [illegible]

39—BOILER HORSEPOWER OF. FACTORS OF OPERATION, ETC.—[illegible]

In choosing coal for boilers the following items should be carefully considered: (1) size of coal most suitable for particular boilers or conditions of use; (2) most satisfactory percentages of fixed carbon and volatile constituents in the coal; (3) nature and amount of coke produced from the coal; (4) amount of ash left by the coal and its melting point and clinkering properties; (5) amount of moisture in the coal and its origin; (6) type of boiler furnace and its relation to coal available; (7) design of fire grates used in furnace; this should be arranged to suit the coal, a small grate generally being more economical; [illegible] arrangement and size of flues and manner in which they are constructed; [illegible] dimensions of chimney; [illegible] as a check on conditions in boiler furnace the gases passing out of chimney should be periodically examined, as completeness of combustion and amount of air used in excess of that actually needed can best be determined by an analysis of flue gases.

Fuel conveyed to mechanical stokers by means of conveyors must not be allowed to fall too far or the air [illegible] will become dust-laden and explosive. Mechanical stokers ordinarily burn less fuel than hand-operated stokers, but are limited to small coal. Even the simplest type of stokers should have careful expert attention.

Boiler Scale.

The composition of the water used in boilers is generally important. The [illegible] matter left on [illegible] should be as small as possible, but it is usually more the [illegible] of this matter than the amount [illegible] that affects boiler operation. Rain or soft water is best, and where [illegible] the water supply should be analyzed and a suitable method of treatment applied. [illegible] hardness may be removed [illegible] soda, or [illegible] hardness is less [illegible] sodium carbonate [illegible]. If the water contains over [illegible] grains per gal. of sodium or potassium sulphates or chlorides it is [illegible]. Water containing more than [illegible] grains per gal. of magnesia [illegible] to cause corrosion [illegible]

Where water supply is not too hard, the feed-water may be heated by means of economizers—a system of [illegible] heated by waste gases from [illegible] gases passing [illegible] always be arranged to [illegible] waste gases [illegible] chimney when [illegible] hard water [illegible] may be more [illegible] in the boiler [illegible] must be provided [illegible] waste [illegible]

The [illegible] steam from the [illegible] should [illegible]

Methods of Water Feed.

[illegible] the steam [illegible]

is returned to the boiler with but little loss, and the instrument is so simply made that it seldom needs repairs. Few injectors, however, can deal with water at a temperature above 100 deg. F.

The usual form of pump for boiler feeding is direct-acting, and either single or duplex. Power pumps run by belting from the shaft are also often employed, but as they cannot run when the engine is down they are subject to great disadvantages.

It is desirable to have two independent means of feeding a boiler, so that if one gets out of action, the other may be relied upon.

The feed-water should enter the boiler near the coolest portion of the water-space, to prevent impinging it on hot plates; it should also be diffused thru a perforated pipe, and not delivered in a direct stream.

To facilitate cleaning of the injector, or pump, a cock should be placed between the boiler and the feeding mechanism, and the latter periodically examined and cleaned when necessary.

Advantages of Superheating.

The question of superheating the steam after it leaves the boiler and before it enters the engine, may be summarized in the following advantages to be derived from a superheating system: (1) It produces dry steam and delivers it in a dry state at a much greater distance than is otherwise possible. (2) It increases volume of steam, due to higher temperature. (3) It gives better use of steam in engine cylinder, less loss by condensation; hence, more efficiency to the whole plant. (4) It lessens strains on boiler. (5) Smaller metal heating surface per h. p. is required. Where superheated steam is employed the pipes for conveying it should be of cast iron or steel (brass and similar metals being deteriorated by the superheated steam). Special lubricants are required on account of high temperature.

Superheated steam supplied to dryers affords a simple means of ensuring the dryness of the steam at the place where it is used.

Before starting a boiler, it should be examined to see that it is in perfect working condition. The pipes should be particularly examined and cleared if necessary, and any grease on inside of boiler should be removed. The boiler should then be filled with water to bottom of water gage, but not so high as in regular use, so as to allow for expansion of water when heated. It is also advisable to open safety valve, when starting, to avoid accidents. In starting, a closed boiler should not be heated, as air will expand but cannot escape and may cause damage. Nor should the boiler be connected to steam main to which other boilers are connected until pressure in the newly-started boiler equals the pressure in the main; otherwise, a "backwork" of steam will result. The boiler should not be heated too rapidly at first, since the metal requires time to "seat itself" properly.

Securing Complete Combustion.

In firing a boiler, the general conditions are such as will secure perfect combustion of the fuel. To accomplish this, the fuel must not be placed so thick on the bars that air cannot pass thru them, while at the same time no part of the grate area must remain uncovered. To insure that the gas produced from the coal will be properly consumed, it is best to stoke in small quantities of fuel at a time, and on alternate sides of the grate, the fresh coal being put in front and gradually pushed forward as it becomes coked. The stoking should always be done when the fire is burning well, not when the chimney is smoking. Keeping furnace doors shut as much as possible will prevent cold air getting to the boilers. When about to clean out scar or clinker, one side of fire should be well charged and the other allowed to die almost out; the clinker may then be taken from this side with comparatively little loss of combustible matter; otherwise, an examination of the ashes will show that they contain a large proportion of only partly burnt coal.

It is best to keep a self-registering record of the draft or temperature of the boiler flues, as well as a close watch on amount of coal burnt per hour. A deficient draft may be due to too narrow or too wide a chimney, to stoppage in the flues, to leaks in the brickwork or in the damper, or to boiler door being left open. (See also auxiliary equipment described under their various heads.)

MANUFACTURER OF EQUIPMENT:
Canton Grate Co.

60—BOILER INSULATION.—The insulation of a boiler is generally accomplished by means of magnesia. This refers to the insulation on top of the boiler. (See also Furnace Insulation.)

Magnesia is sold in several forms. For covering the straight steam pipe it is sold in sections already to place around the pipe and clamp into place with thin flat bands of iron. It is also sold in plastic form for insulating the joints, valves, and other odd places. It also comes in brick form, for use where that is preferable. The amount of fuel saved, thru the fact that this insulation reduces the condensation of steam, is quite large and pays very good returns on the cost. The top of the boiler is usually covered with one row of brick and plastic magnesia spread over the top and into the joints. This insulates the boiler against loss of heat to a great extent. Kieselguhr of a good grade in the form of paste or brick is also a very good insulator. (See also Brick, insulating.)

MANUFACTURER (see catalog section):
Celite Products Co.

61—BOILER REPAIR TOOLS.—It is always necessary to repair boilers from time to time. The flues or tubes are the parts that require the most attention. For cutting out a flue that leaks, chisels are usually used, but an oxy-acetylene blow torch or a special tool made for that purpose only, is more satisfactory. For putting in a flue, an expander is necessary to insure a water-tight connection between the flue and the head or crown sheet. Copper ferrules are often inserted between these surfaces to facilitate obtaining the proper connection or joint. Since the expander enlarges the end of the tube slightly, it is good practice to soften the end of the flue before placing it in the boiler. This is done by heating the end to a dull red heat and allowing it to cool slowly. A beader is another tool used to turn or roll the short piece of the tube which extends beyond the sheet. This protects the contact or connection between the tube and the sheet from any deteriorating influence of the gases of combustion.

62—BOILER TUBES.—All boilers contain tubes, which are fastened to the heads or crown sheets. In water tube boilers the tubes contain the water and the fuel gases circulate around the tubes. In tubular boilers the opposite is the case, that is, the fuel gases pass thru the flues and the water surrounds the flues. Flues are used in order to increase the area of the boiler surface that can be heated to produce steam, which of course increases the capacity of the boiler. Boiler tubes are made of wrought iron or steel, and there is usually a question as to which is the better. Practically all tubes are lap welded, and the ends are tempered by being heated to a dull red heat and then cooled slowly. This process softens the ends so that they can be expanded in place next to the heads of crown sheet without any danger of cracking. Very often tubes that are taken out of a boiler of, say, 18 feet, if not too incrusted, are cut off and sold or used in a boiler of, say, 16 foot length. In other cases both ends are cut from a boiler after removal and a new short length welded on, to make a new tube of the original length. The weld in a case of this kind is flattened to such an extent that it will slip into place thru the sheet without any trouble, and also will not interfere with the passage of the regular flue scraper or cleaner.

63—BONDING POWER.—This is commonly defined as the ability of clays to stand the addition of non-plastic matter. In other words, the clays which will stand the addition of the largest amount of sand or other inert substance, and whose strength is least impaired by this addition, are said to possess the greatest bonding power.

This property is therefore tested by determining the relative strengths of different clays when mixed with varying proportions of sand.

Bonding power is thought to have a definite relation to the plasticity of clay, it being known that clays which are highly plastic usually suffer the least diminution of strength when mixed with non-plastic matter.

A knowledge of the bonding power of clays is of practical value as a guide to making correct mixtures wherever, in the process of clay ware manufacture, it is necessary to mix two or more clays together or to mix an inert material with a plastic clay.

64—BONE CHINA.—The typical vitreous product of England, characterized by its beautiful texture and adaptability to rich decoration (also see Chinaware and the several items under Porcelain.)

The limits of composition given for bone china are: 30-50% of bone ash, 20-30% of china clay, and 20-35% of cornwall stone; also 30-42% bone ash, 15-20% feldspar, 33-35% china clay, and 10-14% flint. Too much clay in the composition causes high shrinkage. Cornish stone is used in nearly all the early bone chinas, since it produces less shrinkage than feldspar or clay. Bone china is glazed with a lead boron glaze, most of which is fritted and burned to about cone 1.

65—BOOKKEEPING SYSTEMS.—Many improvements and short cuts have been made in bookkeeping. The small plant in most cases still uses the simple method of day book or journal and ledger, each bound in one book. The increased business of the larger plants have led them to adopt the newer idea of loose leaf books, so that only the pages that are in actual use are necessary. Further increased business and the introduction of cost accounting as a part of the bookkeeping system led again to the use of control accounts, which are subdivided in smaller books, but which represent certain condensed items in the general set of books. Machine bookkeeping, in which the entries are made on loose leaf sheets, by means of a typewriter, instead of by hand has also found much favor with companies that have a large amount of detail.

BOOT, ELEVATOR, see Elevator boot.

66—BOOTS, RUBBER AND FELT.—The nature of the business requires that practically every clayworking plant has outdoor work, and this is especially true where the pit or shale bank is in the open. Even when the raw material is mined, very few mines are dry enough to obviate the use of boots. Many companies pay the men employed in places where boots are needed the same rate as other men and supply the boots when necessary. In the kiln yard the lack of boots often curtails the setting or emptying output. Boots are generally made in two shapes, rubber for water and snow during warm or medium weather, and felt for the same condition during cold weather. A rubber overshoe forms a part of the felt boot. In addition rubber overshoes or arctics are very serviceable where the height of the snow or water is not more than two or three inches.

MANUFACTURER (see catalog section):
U. S. Rubber Co.

BRICK, BAUXITE, see Bauxite.

67—BRICK, BUILDING.—A classification which includes common and face brick, in fact any brick that is used in the walls and partitions of a building, except that fancy or enameled brick are not included.

BRICK, CHROME, see Chrome.

BRICK, COMMON, see common brick clays under the classification, Clays.

68—BRICK, ENAMELED.—These are brick made with one or two faces covered by an enamel, which is really a glaze or glass. Low grade fire clay has been found to make the best body and the brick must be almost perfect, and free from cracks before the enamel is applied. Only in a few cases has it been found possible to make the enameled brick in one burning operation. In the very large majority of cases the brick are made and burned first just the same as a high grade face brick, very special care to prevent any weaknesses being necessary. After the brick have been made and burned the first time, they are dipped in the glaze and reset and burned the second time, this usually being done in saggers or muffles to prevent the flame from injuring the enamel. The enamel must have the same rate of expansion and contraction as the body of the brick if it is to adhere thereto. Enameled brick are used for interior and exterior facings and decorative effects.

69—BRICK, FACE AND FANCY.—In order to produce artistic architectural effects many manufacturers pay particular attention to the color and appearance of at least one face or surface of the brick which they produce. These brick are called face brick because they are used to lay up the outside or face of a wall in the front or exposed portion of a building. Fancy brick are more elaborate in shape and texture as they are used for decorative effects such as for mantels. Face brick are made by soft mud, stiff mud, and dry press methods. By the selection of clays and care in burning many beautiful effects are produced.

Face brick are also frequently referred to as front brick and pressed brick. The latter term is quite popular among the laymen and is an expression handed down from the time when nearly all face brick were manufactured according to the dry press process. In recent years, however, the stiff mud process has supplanted the other process, but the name "pressed brick" still persists.

BRICK, FIRE, see Fire brick.

70—BRICK HANDLING MACHINERY.—This item refers to all equipment used in handling or conveying finished or burned brick (see Carriers, gravity; Conveyor, belt; Truck, industrial; Conveyor, portable; Crane; Gloves, Loading Machine, etc.). Brick are also handled by clamps or hand-carriers, which hold from six to ten brick, and are equipped with a handle for easy carrying. (See also Car loaders).

MANUFACTURERS (see catalog section):

American Dressler Tunnel Kilns, Inc.
American Equipment Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Steele, J. C. & Sons.

MANUFACTURER'S ANNOUNCEMENT:

The American Equipment Company, 1619 Conway Building, Chicago, Illinois. Patented labor saving machines for setting brick in the kiln, for loading burned brick direct from the kiln, for hacking brick—in fact patented mechanical equipment complete for both stiff mud and soft mud brick yards, reducing labor to a minimum.

BRICK, HOLLOW, see Hollow block and brick.

71—BRICK, INSULATING.—Insulating brick are made of materials that impede the passage and radiation of heat. There are various forms of insulating brick made of infusorial earth, Sil-O-Cel, magnesia, cork, asbestos, fire clay and various combinations of these and other materials. In the clay plant, insulating brick are used around boiler settings and kiln walls and crowns. Their function is to prevent the loss of heat thru radiation, which in clay plants is tremendous. (See tables for insulation values in statistical section.)

MANUFACTURER (see catalog section):

Celite Products Co.

BRICK MACHINE, DRY-PRESS, see Dry-press brick machine.

BRICK MACHINE OIL, see Lubricating oil and grease.

BRICK MACHINE, SOFT-MUD, see Soft-mud brick machine.

BRICK MACHINE, STIFF-MUD, see Stiff-mud brick machinery.

BRICK, MAGNESITE, see Dolomite and magnesite.

BRICK MANUFACTURE, HISTORY OF, see Ceramics, history of.

72—BRICK, PAVING.—Those brick that are made for surfacing a road, street, highway or any place where there is a large amount of hauling. They must withstand the wear and tear of wagon, truck, wheelbarrow and automobile wheels, and of the shoes of horses. One of the tests of paving brick is that characterized as the rattler test. A definite number of brick to be tested is put into a barrel-like arrangement of metal which contains a number of hard steel balls. The brick are weighed before starting and then the barrel is rotated for a definite length of time. The percentage of loss determines whether or not the paving will make a good showing in ordinary work. The loss in weight is determined by the rattler loss and seldom exceeds 22%.

All up-to-date plants use paving brick to pave under coal or clay bins and especially around the kilns. It always was advisable to pave around the kilns and all of the roads traversed by the carts and wagons in the daily routine of hauling coal and ashes, but it is more necessary than ever since the introduction and use of auto trucks.

Paving brick are made from clays of good grade, usually a shale or fire clay. Clays for paving brick manufacture should possess fair plasticity, because they are generally made by the stiff mud process. They should form a dense product and the silica contained should not exceed 70% since this causes brittleness in the product. The brick should have good tensile strength, and should not absorb more than 3% of its weight in water. Paving brick clays should mature between cones 02 and 8, the average clay maturing at cone 2.

The vitrification range should be fairly long and a range not less than 250 deg. F. should exist between the points of incipient vitrification and viscous fusion.

73—BRICK, PRESSED.—A term used to designate face brick. It is in use because all of the face brick were formerly made on machines like the hydraulic press and dry press. (See also Brick, face and fancy, and the description of pressed brick clays under the classification, Clay).

BRICK, REFRACTORY, see Bauxite, Chrome, Fire brick, Silica brick, Dolomite and magnesite, Siloxicon, Zirconia.

BRICK, SAND LIME, see Sand, lime brick machinery.

BRICK SETTING MACHINE, MECHANICAL, see Setting machine.

BRICK, SILICA, see Silica brick.

BRICK, SILICON-CARBIDE, see Carborundum.

BRICK, ZIRCONIUM, see Zirconia.

BRIDGE, see Die, factors of operation.

74—BRISTOL GLAZE is a term applied to a glaze used on stoneware. The glaze is applied to the unburned ware, and the body and glaze matured together at one fire. These glazes are opaque, clear or colored, glossy or matt. The true bristol glaze contains no lead oxide but in its place is zinc oxide, potash, lime, alumina or silica. Sometimes magnesia or barium oxide are used but rarely strontium oxide. Sodium oxide may be introduced by a feldspar and tin oxide is often used to increase the opacity.

Bristol glaze was originally a lead glaze used in Bristol, England. This glaze has practically displaced slip glazes on stoneware bodies. It is used frequently for enamel brick and terra cotta.

75—B. T. U.—Abbreviation for British thermal unit. A B. t. u. is the quantity of heat required to raise the temperature of one lb. of water one deg. F.; for example, from 63 to 64 deg. F. (See Coal, heat value of.)

76—BUCKET, AERIAL.—Aerial tramways which are used to transport materials from one point to another are usually equipped with buckets. They act as receptacles for the materials, and are suspended from wheels or rollers running upon a trolley or track. Monorail systems within the plant are usually also equipped with buckets suspended from wheels. These buckets are of wood or steel and vary in size according to their usage.

MANUFACTURER (see catalog section):

Link-Belt Company.

77—BUCKETS, ELEVATOR.—Elevator buckets are attachments that are fastened to an elevator chain or elevator belt in order to elevate and transport clay that has no large lumps in it from one point to another. The most common use is to elevate ground clay that has gone thru a dry pan or other crushing machine to the screens or storage bin. The minimum size of opening is usually about 4 by 12 ins. They are made of heavy sheet steel, some being pressed from one piece and others made from several pieces riveted together. Elevator bolts are used to fasten elevator buckets to an elevator belt and standard machine bolts to fasten them to a chain elevator.

MANUFACTURERS (see catalog section):

Bonnot Co.
Freese, E. M. & Co.
Green, L. P.
International Clay Machinery Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

BUILDING BLOCK, HOLLOW, see Hollow block and brick.

BUILDING MATERIALS, see Supplies for building construction.

BURNER, OIL AND GAS, see Gas burner and Oil burner.

77A—BURNING BEHAVIOR, TEST FOR.—In order to determine the behavior of a clay in firing, the following data must be obtained.

a. Progressive change in porosity
b. Progressive change in volume.

Knowledge of the following properties will always be useful checking, in a measure, the accuracy of the above determinations: Changes in

c. Color
d. Hardness
e. Absorption
f. Mechanical strength
g. Apparent specific gravity

The clay shall be prepared and the test pieces formed as defined in the Method for Drying Shrinkage, articles 1, 2 and 3. They shall then be dried and the dry volume determined as defined in articles 5 and 6 of the same method.

The test pieces shall be placed in a refractory muffle or sagger as thin-walled as possible, which is set in the test kiln. The test pieces shall not be stacked together too compactly. The test kiln shall be of such size that the effective space available is not less than 1½ cubic feet. The heating may be accomplished by any convenient means but the temperature distribution should be thoroly explored during the first few firings. A set of pyrometric cones of the Seger formulæ as made by Professor Edward Orton, Jr., shall be placed as closely to the stacked up test pieces as possible, but temperature control by means of a platinum-platinum-rhodium thermocouple is required also. The temperature therefore shall be reported in terms of cones and the pyrometric readings, in which correction has been made for the cold junction temperature.

The range of cones used shall cover the firing range of the clay, which must be judged by the operator. Generally, the cones to be placed in the kiln are 014 to 3 for impure, common brick clays; 012½ to 5 for shales and the better types of ferruginous clay; and 02 to 15 for clays of the fire clay type. . Oxidizing conditions must be maintained during firing.

The heating shall preferably be at the rate of 45 deg. C. per hour from the start of the firing until a heat treatment is reached, corresponding to the softening point of the third consecutive cone below that at which the first trial is to be drawn; and 20 deg. C. per hour from that point until the end of the firing. In no case shall the rate of heating be greater than 60 deg. C. per hour nor less than 30 deg. C. per hour for the first period, or greater than 25 deg. C. per hour nor less than 15 deg. C. per hour for the last period.

According to the nature of the clay, test pieces are first drawn at cone 010 for impure, common brick clays; cone 08 for shales and the better grades of ferruginous clay; cone 2 for clays of the fire clay type. A test piece is then drawn from the kiln at each interval of two cones, and immediately before drawing the temperature indicated by the pyrometer shall be recorded. The removal of the test piece from the kiln shall be done as quickly as possible to avoid cooling down the kiln too much. It will be necessary as a rule to increase the rate of application of heat a little after each draw.

Upon removal from the test kiln the test pieces shall be (a) immediately covered with hot sand or (b) placed in a small supplementary furnace kept at a dark red heat and large enough to hold all of the test pieces to be drawn. Upon completion of the firing the auxiliary furnace shall be allowed to cool at the natural rate. (While it is recognized that furnace control by means of a thermocouple is more definite and accurate than with pyrometric cones, especially for testing purposes, trials have demonstrated that the use of cones minimizes the variations between one firing and another due to slight differences in rate of uniformity of heating.)

When cool enough to handle, the test pieces shall be placed in a desiccator containing concentrated sulphuric acid until they have cooled to room temperature. They shall then be carefully inspected and any adhering particles of sand or other material, picked up during firing, carefully removed. They shall then be weighed on a balance to an accuracy of 0.1 gram.

The weighed test pieces shall be placed in distilled water in a suitable vessel and boiled for 2 hours, then allowed to cool to room temperature, while still immersed in water. During boiling, the test pieces shall not be in contact with the heated bottom of the container.

When cooled to as near 20 deg. C. as possible in the room atmosphere, each test piece shall be dried lightly with a damp towel to remove the excess water and weighed in air to an accuracy of 0.1 gram.

78—BURNING, DEHYDRATION PERIOD OF.—Following the water-smoking interval, the kiln temperature should be raised to the dehydration stage of the burn, as it is during this stage that the chemically combined water is driven out of the ware. The chemical water is the water that is intimately combined with the clay and is part of the clay molecule.

The general tendency of the kiln to stick at this temperature is due to the fact that the heat is being absorbed for drawing out the water from the ware. Altho more heat is constantly being added at this point, the temperature does not rise very fast because the clay is taking that heat to separate from it the molecules of water to which it is attached chemically.

Also, it is during the dehydration period that the clay will absorb acids more readily than raw clay does. A dehydrated clay mixed with lime will set like cement. Usually, no particular attention need be paid to the kiln at this temperature, but the burning can be speeded up. Dehydration really starts about 459 deg. C. (842 deg. F.) and is practically complete at 700 deg. C. (1292 deg. F.) that is, it begins at a dull red heat and is completed at a bright red heat. Oxidation is generally carried on at the same time as the finish of the dehydration.

MANUFACTURERS OF INSTRUMENTS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

79—BURNING, FACTORS IMPORTANT TO.—Clay products are influenced in burning, first, by variation of the constituents of the clay, as, for example, the iron content, and, second, by the treatment of the clay. Iron affects clay products in various ways, depending upon (1) variation of the amount of iron content, (2) variation of the size of grain, (3) variation of the mineralogical form of the iron, and (4) the influence of the metals accompanying the iron in the clay.

White burning clays contain from .01 to 1.0% of iron. Red burning clays usually contain from 4 to 7% of iron. Iron may be present in the form of ferric hydroxide, which form it takes in oxidation. Limestones are low in iron. The red color of clays is not proportional to the iron content, as 4 or 5% of iron may produce the same color as 7 or 8%. In buff clays it is thought that the color is due to the chemical influences of other elements on iron.

The variation in size of grain ranges from (1) precipitated or colloidal forms whose fineness exceeds all forms of measurement, and (2) concretionary or granular forms in which the grains are of appreciable size.

The precipitated form of the iron is necessary to the development of either the buff or red color. The addition of red slip to buff slip gives salmon or flesh color. Concretionary or granular iron produces speckles. Ferric oxide, ferrous carbonate and ferrous hydroxide, are the most important forms of iron found in clay. Ferrous hydroxide predominates in surface and glacial clays. Ferrous carbonate is often found in deep cuts in clays and the clay is usually a blue, tough, adhesive, hard pan. Fire clays and shales contain the iron as carbonates or pyrites. Iron pyrite is found in common old rocks and is easily formed and easily decomposed again. Oxidation even at common temperatures easily converts it into the sulphate. Sulphates are readily changed by organic matter to sulphides. Good reds may be obtained with either ferrous or ferric salts of iron.

Form of Iron Important.

The mineral form of iron is important for two reasons: (1) the tendency of some minerals to crystallize and gather in a concretionary mass, and (2) the great difference in treatment which different minerals require in burning.

Shale and fire clays characteristically contain their iron in the carbonate or sulphide form. The external clays have been more or less oxidized by weathering, and in these strata the iron is likely to become ferric.

All forms of iron gather in concretions or crystallize, it being simply a question of degree. Fe_2O_3 and ferric hydroxide are least prone to do this. Ferric concretions in clays generally represent reoxidized concretions of the carbonate.

Iron carbonate seems to exist in the disseminated form or as concretions equally abundant. In dealing with clay in which iron carbonate is known to be present, a finer grinding is necessary if specks are detrimental to the ware. Lumps of iron in the clay produce black specks. Iron pyrite is invariably found in granular form either large or small, but never small enough to give red color; it always produces black specks.

Seger classified buff burning clays in two groups: (1) Those of such high iron content as to burn red normally, but which are sufficiently calcareous to enable the lime to destroy the red iron color and form a yellow compound of iron and lime; and (2) those low in iron and high in alumina, which would normally burn pale red, but develop a yellow color, due to the formation of an alumina-iron compound.

Some minerals give trouble as reducing agents, such as S, C, etc. They prevent iron from being oxidized, altho in themselves they do not affect the color. Sulphur is generally always detrimental.

From 3 to 5% of bituminous matter, or one-sixth to one-third enough fuel to burn clay, is often present in clay. Part of this is volatile and burns with intense heat when subjected to burning temperature. A remedy is to close the kiln and stop the fire.

Vitrification.

In red clays vitrification usually begins at about 900 deg. C. (1652 deg. F.), there being five different stages of vitrification: (1) condensation of clay; (2) incipient vitrification; (3) complete vitrification; (4) viscous vitrification; (5) fusion.

The iron phenomena at complete vitrification are: (1) the development of the normal ferric iron color, red or buff; (2) the development of normal ferrous color by reduction; (3) the development of abnormal black cores by faulty oxidation; (4) the blue-stoning, or normal change, from ferric to ferrous by increase in temperature by oxidation; (5) reoxidation or flashing.

Evidence tends to prove that red color is due to free iron and, as vitrification becomes more perfect, the color darkens to brown or black. The maturing temperature, or period at which the change of color takes place, varies from Cone 1 (at which point clay mass contains only 50% clay substance) up to Cone 9 in highly sandy clays. In other words, the maturing temperature depends on the composition of the clay.

Soft fluxes, such as lead or alkalies, which promote silicate formation tend to bring iron into combination and destroy the red color of ferric oxide, or its red color may be due to ferric silicate which forms black ferrous silicate at a certain temperature. Bluestoning is thought to be the partial change of Fe_2O_3 to ferrous silicate. Flashing is produced by alternate reduction and oxidation. Quick cooling leaves iron in ferrous condition. Carbon left in the pores leaves defects and also reduces Fe_2O_3 to FeO, causing a black color.

(For factors of kiln operation in burning, see various entries under Kilns; also see additional items under Burning.)

MANUFACTURERS OF INSTRUMENTS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

80—BURNING; NOTES ON COMPARATIVE METHODS OF TRANSMITTING HEAT.—It is always a good plan to analyze furnace conditions and to study the manner in which the heat is being distributed thruout the furnace and the kiln. The fuel in a down-draft kiln burns from the fire box to the bottom of the kiln floor. A long flame coal will burn a long distance; a short flame coal gives localized heat.

A large amount of the transfer of heat from fuel to clay ware is accomplished by radiation. The radiation of all bodies increases with the temperature, and a formula is often used to express this fact.

Thus

$$E = K\,(T_1^4 - T^4),\text{ in which}$$

E=energy (heat); k=constant which varies with each material; T_1=temperature of the hot surface or body; and T=temperature of cold surface or body.

Radiation is one of the most powerful factors of transferring heat, and is very important in the burning of clay ware. Radiation takes place in a straight line from a wall, muffle, furnace, etc.

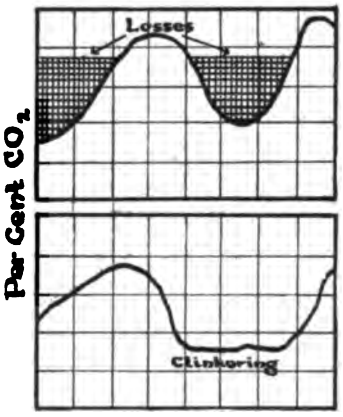


Fig. 1. Showing the Variations in Percentage of CO_2

The faster the kiln is heated after the oxidation period is completed, the greater the saving in fuel.

Convection is also an important factor of transmitting heat (by convection is meant the creation and utilization of currents of air, steam, etc., by means of which heat may be conveyed to any portion of the kiln). Heat can be conveyed in an indirect manner of firing. By introducing steam into a fire box, the water can be dissociated into its component gases and the gases in the fire box simultaneously cooled. In this manner, heat is taken from the furnace and then let free in the kiln proper. This is done in oil firing, and for this reason steam is used instead of air. It is also easier on the refractories.

The property of conduction is also very important in burning, since it is impossible to heat ware up any faster than it is able to absorb the heat. The amount of surface exposed per unit weight of ware is also important. The greater the area of the surface exposed the better the opportunity for taking up heat from the surroundings.

By-products gas could be used in burning clay products, and blue gas may also be used with satisfaction.

It is a waste of time and fuel to follow the procedure of uneven firing, such as once an hour. A curve showing the percentage of CO_2 gases during the burn would reveal a wavy curve showing alternating high and low percentages of carbon dioxide (see Fig. 1). The area formed by the loop showing low percentages of CO_2 (the shaded portions) represents losses and a waste of fuel. If hand-firing could be properly handled it would be the most economical method of burning. In the case where a producer gas is used, there is a 15% loss at the very beginning, due to the loss in sensible heat. Even with this loss, however, the steady flow of heat from the gases makes the gas producer more economical.

The losses due to black smoke issuing forth from stacks of kilns are not nearly so great as in the invisible conditions where enormous quantities of excess air rush thru the kiln.

A gas analysis is very useful in bringing about fuel economy and is simple to obtain. The air factor of waste gases may be expressed as

$$\frac{100}{100 + 4.76 \text{ percentage of } O_2}$$

the minus sign being generally used. The constant 4.76=the amount of air for every per cent. of oxygen.

Powdered Coal a Possibility.

Bleininger thinks that powdered coal can be used for the burning of common brick, and that eventually the use of this fuel will become more widespread. He also believes there is room for a furnace that will control the air supply, and that the automatic stoker can be used as in rotating calcining kilns.

In hand-firing, care must be taken not to have too heavy a fuel bed on the furnace grates, since this gives too much friction to the gases passing thru the furnace. On the other hand, if the velocity of the gases is too fast, some of the gases will go out of the stack before combustion takes place, thus involving a loss of heat energy and waste of fuel. There must not be too much draft at the end of the firing, and it is always advisable to use an instrument to keep track of the draft. A U-tube can be used to connect to the flue and readings taken as often as required.

A draft gage does not measure velocity but does measure pressure.

Thus, three important points to observe in burning (rather, to be observed in the control of the burning stages) are draft, temperature and composition of flue gases.

Use a 17-in. pressure (water) on natural gas heating for best results when that fuel is used.

The damper cannot solve the whole problem of burning; the setting must also be right. Damper control is of no avail if the resistance of the ware to the gases is not proper at the bottom of the kiln.

Definition of Draft.

Draft is the movement of gases caused by a difference in the temperature of the gas in a flue or stack and in its equivalent volume of outside air. It is also a similar movement caused by some force such as a blower, fan, vacuum or steam jet.

A damper is effective within certain limits, but is not a first and last resort. With too little draft the heat input is less and the kiln may be losing heat.

Wave burning has been found to be without value.

A pyrometer will tell the draft that gives the best heat effect, and the draft gage and pyrometer should be used jointly.

Forced draft simply gives a greater pressure in the kiln and not so much a greater volume of gases. Rapid burning is obtainable with forced draft.

Draft varies as the square root of the height of a kiln stack. The limit for a stack for kilns is about 150 ft. A certain temperature (about 273 deg. C. or 523.4 deg. F. above the outside temperature) is the maximum draft point. Above this temperature the draft does not increase.

In a pottery kiln, only five lbs. of fuel out of every 100 lbs. are actually used in firing the ware. The heat losses are due (a) to unburnt fuel, (b) to waste gases, (c) to heat passed thru the walls, and (d) to heat left in the fired ware.

Insulating material increases the heat inside of the kiln.

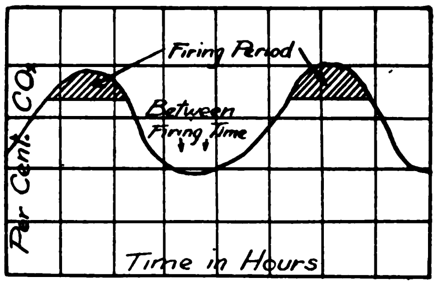
In finishing the firing of a kiln, cones or draw trials should be used, since a pyrometer leaves out a very important part of the burning; namely, that of time.

Theoretically, it is possible to burn any clay in 24 hours.

MANUFACTURERS OF INSTRUMENTS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

81—BURNING, OXIDATION PERIOD OF.—Nearly all clays contain carbon, organic materials and pyrites. The organic materials are usually roots, tarry matter, bituminous matter, anthracite materials, and graphitic matter. Combustion cannot take place without the presence of oxygen and oxidation must be accomplished at the temperatures at which the clay is still porous. This temperature varies with different clays, and oxidation may begin as low as 500 deg. C. (932 deg. F.), and is probably ended by 900 deg. C. (1652 deg. F.). However, most clays are oxidized at 1200 deg. F., except fire clays, which require a higher temperature. During this period, the following changes take place: (1) the oxidation or burning off of combustible matter; (2) the expulsion of the remaining sulphur from pyrites; (3) the driving off of carbon dioxide; (4) the oxidation of any ferrous iron to the ferric condition.

To accomplish oxidation of clay, two things are very necessary: (1) the temperature must be held for the time being; (2) plenty of air is required in the kiln.



How the Percentage of CO_2 Should Appear After Firing.

The object of the oxidation period is to burn out the carbon at the minimum temperature with an ample supply of air. Smoky air does not oxidize. Some seem to think that temperature is the only criterion during the oxidation period, but plenty of air is also very essential.

Iron sulphite is broken up and the sulphur goes out of the kiln as sulphur dioxide gas. Ferrous carbonate is also broken up and the carbon passes out of the kiln as carbon dioxide. The reaction for this is $FeCO_3 + \text{heat} = FeO + CO_2$ and $2FeO + O = Fe_2O_3$. Thus, during the period of oxidation all of the carbon is burned out and the iron is oxidized to ferric oxide. Ferrous oxide is a very active flux and brings about vitrification before the ware is really ready for it; hence, it must be changed into the ferric form which slows up the action.

Manufacturers of sanitary ware, glass pots, etc., do not pay any attention to this period of burning.

One very important item in oxidation is the necessity of having the furnace grates clean. In order to tell when a kiln is completely oxidized, small test pieces, which must correspond to the size of the pieces of ware that are being burned, are placed at certain places in the kiln. They are then taken from the kiln at intervals, broken and inspected. If the ware is not completely oxidized there will be a black or grey core in the center. If the ware is sufficiently oxidized, the cross section of the broken piece will be uniform in appearance and color altho it may not have the same color as the outer surface.

It is best not to fire too often during the oxidation period, since this raises the percentage of carbon dioxide in the kiln, whereas there should be an excess of air at this stage of burning. Ordinarily, firing at about 45-minute intervals is sufficient during the oxidation period. The CO_2 curve should show the highest percentage of carbon dioxide in the kiln immediately after such firing, as illustrated in the accompanying curve. It is this period, above all other stages in burning, during which there should be plenty of air in the kiln, since it is by means of the air which combines with the carbon in the ware that the carbon is removed in the form of carbon dioxide.

The clay at the end of the oxidation period is very porous and of low mechanical strength. Also, after oxidation is completed, the burning can proceed rapidly without much danger.

Oxidation may take place without the aid of heat, however, the process going on slowly when clay is exposed to the weather. In this case, both FeS_2 and $FeCO_3$ may be changed to oxide, and even organic matter may be partly eliminated.

A porosity of clay materially affects the oxidation process. A loose, coarse-grained clay will permit the necessary changes to take place more readily than a fine-grained, close textured clay, as the latter checks or retards the entrance of the oxidizing gases into the mass. For this reason, grog is sometimes employed to open the grain.

The periods of oxidation and dehydration somewhat overlap, and during the temperature interval in which they occur there are few, if any, reactions going on between the clay particles, but as vitrification approaches chemical union takes place between the different minerals in the clay, and as it goes on involves an increasing number of elements in the reactions, which becomes exceedingly complex.

A red burning clay will have a much brighter color at the end of the oxidation period.

Water-smoking is frequently referred to as "blue smoking." (See also Black coring, and Carbonaceous matter.)

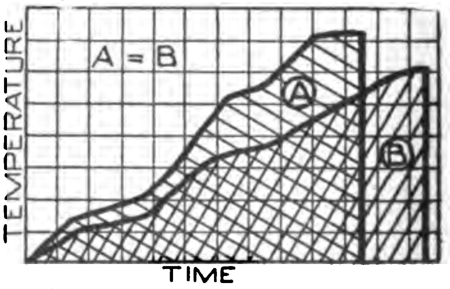
MANUFACTURERS OF INSTRUMENTS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

82—BURNING; RESULTS OF OVERFIRING.—Overfiring of the clay causes the production of a spongy structure which does not give strength to the mass. This spongy or vesicular structure is due to the fact that the clay becomes viscous during overburning, and the gases passing thru the viscous mass are caught and held there when the clay cools.

MANUFACTURERS OF INSTRUMENTS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

BURNING SYSTEMS (see all entries under Kilns and Kiln accessories, also Forced-draft, Grates, Kiln fire boxes, Kiln floor brick and shapes, and Kiln experts).

83—BURNING, TIME-TEMPERATURE FACTOR IN.—The time-temperature factor is one of the important considerations in burning, yet is seldom given sufficient attention. A higher temperature in burning when used to burn clay ware usually means a less amount of time for maturing the ware than when a lower temperature is used. Thus, the burner has the choice of these alternative methods, but his choice will depend, or be affected somewhat, by the raw material used, the kind of ware to be burned, and the size of the kiln. The question of the kind of raw material used is the most important.



Time-Temperature Curves for the Same Clay at Different Rates of Burning.

The more rapid the rate at which the ware is fired, the longer the fire must be held at the end of the burn (at the soaking period). The slower the rate of fire, the less the need of holding the fire at the end. It is strongly advisable that every burner should determine how long it takes to complete his burn under different speeds and temperatures.

For burning quickly, a safe-burning clay must be had. Some clays absolutely will not stand up if they are subjected to quick burning. A high lime clay might be vitrified if burned in small units such as in the tunnel kiln.

A method of determining the time-temperature factor in burning is illustrated. Take a certain clay and plot time-temperature curves for burning it at different speeds and temperatures; upon measuring the areas beneath the various curves, it will be found they are equal in each case for slow and fast burning, and for high and low temperature, maturing or finishing temperatures. The area under the curve is the time-temperature treatment required by that particular clay or body to burn it properly.

MANUFACTURERS OF INSTRUMENTS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

84—BURNING, VITRIFICATION PERIOD OF.—When the oxidation period is over, a contraction in the clay takes place. At about 1850 deg. F., a unique change occurs during which time heat is actually given off from the ware itself. This fact was discovered by Le Chatelier. The change is due to the breaking down of the clay to a compound known as sillimanite, or $Al_2O_3SiO_2$.

Magnesia oxide will also contract as a higher temperature is reached without fusion or fluxes; this is caused by a colloidal contraction.

As the temperature of the clay is increased the contraction becomes more marked. The earthy mass is thus being converted into a rock. The alkalies, lime, MgO, FeO, etc., serve as fluxes. They begin to fuse below their regular fusion point and a complex eutectic point is formed. The whole mass sums up into a distribution of all of these oxides thruout the entire clay mass.

Iron, lime and clay form a complex compound. They form a matrix which softens and thus causes contraction. In this condition the clay is subject to surface tension. The skin is like rubber and tends to contract. The fused mass has a tendency to form into a drop or sphere much like water does. There is a tremendous force causing this formation into a drop which is not usually realized.

Vitrification is the contraction and filling up of the pore space of the clay. The surface tension exerts a pressure which brings about the contraction of the whole mass.

Vitrification is frequently measured by absorption which is simply

$$\frac{\text{Wet Wt.} - \text{Dry Wt.}}{\text{Dry Wt.}} \times 100 = \%\ \text{absorption.}$$

However, absorption is not as accurate a method of determining the state of vitrification of the clay as is the porosity. The formula for determining the porosity of a clay or piece of ware is—

$$\frac{\text{Wet wt. in air} - \text{dry wt.}}{\text{Wet wt. in air} - \text{suspended wt.}} \times 100 = \%\ \text{porosity.}$$

The clay mass at the vitrification point actually expands altho the piece of ware shrinks, due to the fact that the pore space is gradually being eliminated.

There are two stages of vitrification —incipient and complete.

In incipient vitrification the clay is heated up until it is sufficiently soft to make the grains stick together, and enough to prevent the recognition of any except the larger ones; but the articles have not softened sufficiently to close up all the pores of the mass.

Complete vitrification is caused by a further increase of temperature, ranging from 50 deg. F. to 200 deg. F., or even more, during which the softening of the grains has progressed sufficiently to close up all the pores and render the clay mass impervious. Clays burned to this condition of complete vitrification show a smooth fracture with a slight luster. The attainment of this condition also represents the point of maximum shrinkage. (See also Porosity.)

MANUFACTURERS OF INSTRUMENTS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Brown Instrument Co.
Engelhard, Chas., Inc.
Hadfield-Penfield Steel Co.

85—BURNING, WATER-SMOKING PERIOD OF.—Primarily, as this is one of the most important intervals of burning, the clay goods should always be thoroly dry before being set in the kiln preparatory to burning. The temperature of the kiln during the water-smoking period should be brought up as fast as possible to the boiling point of water (212 deg. F.), and a good, strong draft maintained. To obtain a good strong draft a hot stack is essential, and it may be necessary to heat the stack up with an auxiliary fire built at the bottom of the chimney. Artificial draft is desirable, or the gases may be by-passed by using a fan set, connected with the main stack. This scheme has been used with good results on some plants.

Sulphuric acid is also troublesome during the water-smoking stage. The vapor liberated from the ware nearest the hotter portions of the kiln condenses upon the cooler brick in the bottom of the kiln as it comes into contact with them and this water in turn absorbs the sulphur gases resulting from the burning of the coal, so that sulphuric acid is formed which unites with the calcium or lime in the clay to form a compound which is called calcium sulphate, but more commonly known as scum. This scum spoils the appearance of the ware and sometimes makes it unsalable. A good draft is mainly needed to eliminate this difficulty. Also, the use of a fuel which contains no sulphuric acid will help. A coal which gives 1% of sulphur produces considerable sulphur gas in the kiln.

After bringing temperature of kiln to 200 deg. F., quickly raise it to 300 deg. F. and hold. Some clays will stand 400 deg. F., but the above temperature is best in most cases to maintain for a while. Both temperature and draft are important at this particular stage.

The temperature of the kiln can be shown at this point by a thermocouple or water-smoking thermometer; the latter is preferable, as it is more sensitive and a thermocouple may easily be off about 50 deg. F.

A copper-constantan couple is recommended for use, as it is cheap and simple to make up. It can be used on an ordinary millivolt meter or recorder, but a new table must be provided. Porcelain protection tubes should be used over the thermocouple. Take the thermocouple out of the kiln at 1,600 to 1,700 deg. F., as this is about the limit of temperature the thermocouple will stand.

By sticking a cold iron or metal rod in a flue, it is easy to tell whether or not the water-smoking period has been completed. If any moisture collects on the cool rod due to condensation, it is evident there is still some water vapor in the gases which come from the ware in the kiln; but if no moisture collects upon the cool rod, this indicates there are no water vapor gases coming from the kiln, hence all of the water in the ware has been driven out. Allowance must be made, however, when using a rod, for the fact that a wet or damp flue or foundation will cause an error in information after the kiln proper is dry. The water-smoking may be thoroly completed, but if there is moisture in the flues or foundation it will show up on the rod, and thus cause a delay in raising the heat of the kiln.

It is imperative that a uniform temperature exist thruout the kiln at the water-smoking period of burning.

86—BUSHINGS.—A cylindrical piece of metal or wood which fits between a pulley and a shaft. In the case of a tight pulley a bushing is not used very frequently; but when the pulley is made for a shaft larger than the one on which it is being used a bushing bridges the gap between the pulley and the shaft. At times, however, a bushing is used with a split pulley which does not employ a key for fastening itself to the shaft, depending rather on the clamping effect exerted on the bushing. This is the use generally made of wooden bushings, partly because by the substitution of various sizes of bushings a pulley can be used on many sizes of shafts. A clutch or loose pulley should always be equipped with metal bushing. Bronze or brass is the most satisfactory material. The bushing should be fastened to the pulley and adequate provision made for lubrication between the shaft and the bushing. The bushing being softer than the shaft receives all of the wear, and when worn too much can easily be replaced. When a bushing is not used the entire pulley must be replaced at much greater expense.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Link-Belt Company.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

BUTTONS, ETC., PORCELAIN, see Porcelain, soft, dull feldspathic.

C

CABLE CONVEYORS, see Conveyor, cable.

CABLE, STEEL, see Rope, wire.

86A—CALCAREOUS.—A term used to designate clay that has a predominating quantity of lime as one of its constituents, that is a quantity that has a marked effect on its behavior, tho at times only five or six per cent.

87.—CALCITE.—This mineral commonly known as lime carbonate or limestone ($CaCO_3 = CaO$ 56%, CO_2 44%) occurs principally in clays of comparatively recent geological age, altho considerable quantities are found in some shales. It is easily detected, being easily dissolved in weak acids, and effervescing violently when a drop of muriatic acid or vinegar is applied to it. Calcite is seldom present in grains visible to the naked eye, but in some clays, as well as some other minerals, it may form concretions. A number of the lacustrine and glacial clays of Wisconsin and Michigan contain large quantities of lime carbonate, and some of those found in other states are highly calcareous. Texas flood-plain clays often contain a considerable percentage of lime carbonate. The presence of calcite in any clay may be very injurious and should be investigated thoroly. If the burning is carried only far enough to drive off the carbonic acid gas, (which may be 900 deg. C., 1652 deg. F.) the result will be that the quicklime thus formed will absorb moisture from the air and slake. No injury may result from this if the lime is in a finely divided condition and uniformly distributed thru the ware, but if, on the contrary, it is present in the form of lumps, the slaking and accompanying swelling of these lumps may split the ware. If the burning is carried high enough the lime, iron and some of the silica and alumina of the clay will unite to form a new complex compound which will prevent any danger of air slaking. The presence of lime tends to counteract the dark color of iron and in the case of shales and surface clays will produce a buff color in a clay that would otherwise burn red. The smallest percentage of lime in fire clay reduces its refractoriness considerably. If lime is present in sufficient quantity the clay may soften very rapidly. Cases are known where the points of incipient fusion and viscosity were only 41.6 deg. C. (75 deg. F.) apart. Clays of this character cannot be worked economically.

Some writers put the allowable limit of lime in clays as low as 3%, but, as a matter of fact, a good building brick can be made from a clay containing as much as 20 to 25%, provided it is in a finely divided condition, and a vitrified ware is not attempted. If, however, the quantity of lime contained in the clay is in the form of pebbles, much damage may result from bursting of the brick, when the lumps of burned lime slake by absorbing moisture from the air.

Clays containing a high percentage of lime carbonate are used, especially in Michigan, Wisconsin and Illinois, for making common brick, common earthenware, roofing tile, and some terra cotta.

(See also Calcium carbonate and the several items under Burning.)

Limestone pebbles in clay are removed by rolls or washing. Fine grinding and screening will remove this trouble because the effect is diffused.

88—CALCIUM CARBONATE.—This chemical compound is used in the manufacture of porcelain. It produces rapid vitrification of a body but gives slight trouble from blisters, due to CO_2. It produces some bodies of good strength tho rather poor in color.

The presence of calcium carbonate in crude clay is generally a source of trouble and loss, if not removed or counteracted in some way. One trouble from this source is explained under Calcite to which the reader is referred. In addition in many cases the CO_2 contained in the calcium carbonate is driven off and replaced by SO_3 from compounds in the clay or in the gases that result from the combustion of the coal. This forms calcium sulphate which is the chief cause of scum on clay products.

The addition of carbonate of barium to the crude clay is the best preventive of scum. (See also Dryer-white; Soluble salt; Soluble salt, prevention of; Barium carbonate; Kiln-white and Scum.)

89—CALCIUM FLUORIDE.—A substance sometimes used in porcelain bodies. It has a tendency to cause blistering. Slow heating and cooling of the ware decreases this trouble. (See also Fluorspar.)

CAP, BLASTING, see Dynamite, and Powder, blasting.

90—CAPITAL.—The amount of money invested in a business, that is, the amount actually put in as distinguished from any profits that have accrued. Permanent or invested capital is the amount actually and permanently invested in land, buildings, plant and equipment. Operating capital is that, in addition to the above, which is necessary to carry on the business in question. Operating capital is used to pay labor, coal, supply and royalty bills, and is returned from sales. In accounting work the item of capital on a balance sheet usually is the sum of the two amounts described above, and that amount is the one which is used for figuring any percentage of profits. Both permanent or invested capital and operating capital may vary from time to time, as more money is put in or taken out or more is spent for equipment. It is often difficult to distinguish between repairs, replacement and capital investment, when considering a certain expenditure.

CARBIDE LIGHTING SYSTEM, see Lighting system, portable.

91—CARBONACEOUS MATTER.—This text includes all matter of carbonaceous character, most of which is of vegetable origin. Few sedimentary clays are entirely free from it. Carbonaceous material occurs in clay in three different forms:

1. Vegetable tissue—wood, stems, leaves, etc.—in which the form is only slightly changed; this kind of carbonaceous material is usually found in clays of recent origin. Being organic matter, and seldom present in amounts exceeding 1%, it rarely affects the color of the raw clay and burns out easily, causing but little trouble.

2. Carbonaceous matter of asphalt or bituminous character, which burns readily at a low red heat because of the highly combustible gases given off from it. It is found in some clays and many shales, especially those associated with coal seams. It may be present in shales in variable amounts up to 10%; where it exceeds this amount the shales are not workable. In some instances, even 5 to 6% causes considerable trouble in burning.

3. Hard, or coaly carbon, resembling anthracite. This grade burns slowly and gives off few combustible gases.

The first of these groups causes no trouble except when it occurs in the form of sticks, thick roots, etc., and has to be screened out.

Concerning the other groups, carbonaceous matter often serves as a strong coloring agent of raw clays. If present in small amounts it tinges them gray. Larger amounts cause a black coloration. In fact, this property may be so strong that it masks the effect of other coloring agents such as iron. For example, two clays colored black may burn red and white respectively, because one contained much iron and the other none, and yet, owing to their original black color, this could not be definitely foretold.

Asphaltic carbon, aside from its coloring action, frequently causes trouble in burning, producing black cores, or even swelling and fusing of the brick. In addition, it may keep the iron in a ferrous condition and prevent the development of the best color effects in the ware. This is due to the fact that carbon has a strong affinity for oxygen, much stronger than that of iron, and as long as any carbonaceous matter remains, the oxidation of the iron is prevented or retarded to a harmful degree. Experiments conducted by Orton and Griffin (see Second Report of Committee on Technical Investigation, Indianapolis, 1905) indicate that the remedy lies in burning off the carbon in the temperature interval between 800 deg. C. (1,472 deg. F.) and 900 deg. C. (1,652 deg. F.), as below this the oxidation of carbon does not proceed rapidly and above this there is danger of vitrification beginning and oxidation being stopped. The procedure, therefore, is to drive off the moisture first, then raise the heat as rapidly as possible to an interval between the above temperatures and hold it there until the ware no longer shows a black core denoting ferrous iron.

In order to burn off the carbon and oxidize the iron, air supplying oxygen must be drawn into the kiln during burning, since the combustion gases from the fuel will supply none. Oxidation may be quickened by increasing the amount of air entering the kiln and by reducing the density of the clay as much as possible. If this is not done, there is a danger of swelling, perhaps even of complete fusion of the interior of the mass caused, first, by the closing of the pores before all the carbon is burned off, and, second, by the formation of an easily fusible ferrous silicate. When the carbon is all burned off the iron has a chance to oxidize.

If there is a high asphaltic carbon content in the clay, the oxidation should be carried on with as little air as possible, otherwise the heat generated by the burning hydrocarbons may be so intense as to cause vitrification before the oxidation is completed.

In relation to the effect of water on black coring, if the brick is set wet it requires such a high heat in the early stages of firing to drive off or evaporate the water that other changes, such as oxidation of the carbon, will be retarded, and vitrification ensue before the process is completed. (See also Black coring and Burning, oxidation period of.)

CARBONIFEROUS, see Geological ages.

92—CARBORUNDUM.—Produced in an electric furnace by heating together sand, sawdust, and coal. It is a carbide of silicon, has the formula SiC, and is crystalline in nature. It is crushed and made into shapes and forms as desired by using a bond of fire clay, about 15% tar, sodium silicate or other similar substances. It is highly refractory, and at the temperature of 2,220 deg. C. (4,028 deg. F.) it begins to separate into carbon and vaporous silicon. It is sometimes called silicon-carbide. This material oxidizes slowly above 1,470 deg. C. (2,678 deg. F.), and is used as a refractory for lining copper and brass furnaces, for tunnel kilns and to some extent electric furnaces and clay and zinc retorts. It is also an ingredient of grinding wheels.

93—CARD INDEXES.—Very few offices to-day are not equipped with some kind of a card index, but there are so many uses to which one of these devices or systems can be put that their use can easily be enlarged. The sales department can keep records of the sales to different dealers or different localities or of different classes of materials. The stocks of different shapes, of a fire clay, sewer pipe, china ware, flower pot, earthenware, drain tile or other plant can be successfully kept thereon. In the purchasing department the prices of each item can be kept thereon and the employment and time-keeping departments can list the employes in this way. In addition to the usual type of card systems where the cards are kept in drawers, there are visible systems in which one line of each card is visible, thereby affording a visible index. These are usually mounted on a flat frame which can be hung on the wall or can be mounted in vertical hangers which swing around a center support or stand. Many plants use one or the other of these systems to keep track of their active orders, using one card for each order, and the location of the card indicating the status of the order. Follow up sales work can be shown very successfully on a card system.

94—CAR, DRYER.—These consist of a body or frame mounted on four wheels, the gage of which is usually about 24 or 36 inches. The ends of the bodies are fixed so that they will take up any jar that is encountered, and the ware on the car is thereby damaged as little as possible. Dryer cars are made entirely of metal except that some of the decks on which the ware is placed are made of wood. This is necessary when the moisture in the ware would tend to discolor the product on account of its contact with iron or steel. The axles on dryer cars have roller bearings, and the box can be packed with either grease or graphite. The latter is preferable because the grease tends to gather dust and dirt which packs and further because the grease softens and runs when it reaches the zone of high heat. If grease is used in the boxes of dryer cars the boxes should be inspected and cleaned out after every few trips thru the dryer. When the product of stiff-mud machinery is placed on dryer cars, one, two or three decks are used, the number of decks depending on the necessity for care in handling the ware. For the output of soft-mud machinery and for silica brick and shapes, cars are used that have racks. These racks consist of small angle irons which are riveted to the frame of the car so that they are always horizontal, and are usually not more than four inches apart. Pallets holding only one brick high are placed on these angle irons, and the ware dried in that way so that no piece of ware touches another piece. In some cases the boxes of these rack cars are equipped with springs in order to prevent any irregularity in the track damaging the ware, which is very soft.

MANUFACTURERS (see catalog section):

Easton Car & Construction Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Philadelphia Drying Machinery Co.
Rodgers, L. E., Engineering Co.

Robinson, Frank H.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

International Clay Machinery Company, Dayton, Ohio, announces a new car bearing, flexible, easily installed, and equipped with an oil reservoir. Irregularities in the track or even a sprung axle will not cause binding in the bearings. A complete line of standard or special cars can be furnished on short notice. See our pages in catalog section.

95—CAR, DUMP.—Cars for moving overburden, clay, shale, coal, etc., are usually equipped with dump bodies, and called dump cars. The amount of material to be handled and the cost of unloading make it imperative that it be done as economically as possible. Dump cars are provided therefore and they can be made to dump on the side, on the end, or thru the bottom. The side and end dump are made with either a flat bottomed or V-shaped bed. In the former there is a pivot in the center of the bed underneath, and it is dumped by men raising the side opposite to where it is desired to dump it. The V-shaped type is loaded with the point down and a track is provided at each end which guides the body as one side is pulled down. This dumps the load. Bottom dump cars are dumped by a lever on the side. In many cases a catch can be provided to trip the lever and dump the load automatically when the car is over the bin or other place where it is desired to unload. (See Cars, mine, pit, etc.)

MANUFACTURERS (see catalog section):

Clearfield Machine Shops.
Easton Car & Construction Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

Easton Car & Construction Co., 200 Fulton St., New York, N. Y. Easton Rocker Dump and clay handling cars, as well as dryer and kiln cars, can be furnished for meeting every car haulage requirement in the ceramic industry. Prices and specifications on cars and narrow-gage railway equipment gladly furnished upon request. See our page in the catalog section.

International Clay Machinery Company, Dayton, Ohio, have just published a new catalog of all types of industrial cars. Being engineers and designers of complete clay plants, and manufacturing all equipment necessary for such, they are peculiarly well fitted to give advice on your hauling problems. See our pages in catalog section.

95A—CAR, KILN.—A kiln car is used only in a tunnel kiln. The frame is made of metal with wheels that fit on a track just as any other dryer, pit, mine or railroad car. The bed is either made of refractory material or of metal covered with some insulating or refractory material. Much of the trouble that has been encountered in the operation of tunnel kilns in the past has been due to the kiln cars. In many installations the cost of repairing the dryer cars has been large.

The bed, therefore, should be constructed so that the changes due to the expansion and contraction caused by the successive passages thru the kiln will not destroy the bed. (See also Kiln, tunnel.)

Car for Tunnel Kiln Before Placing Refractory Cover.

MANUFACTURERS (see catalog section):

Easton Car & Construction Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.
Toronto Foundry & Machine Co.

96—CAR LOADERS.—This item refers to a mechanical equipment suited to loading cars. Naturally there are several different types. For loading from kiln or stock pile there are several types of roller conveyors, which require no power for operation unless the distance is large. Even then the power used is very small and is used only at one point. One man loads the ware onto the conveyor and the force of gravity carries it around curves and a considerable distance to where another man takes it from the conveyor and places it in the car.

Under other conditions the industrial truck is found to be more efficient, and its use is increasing daily. The belt conveyor is best suited for loading crude and unprepared clay, and ground fire clay is often loaded in this way from a bin. There is also a type of fan or blower used for loading ground clay which obviates the use of shoveling even in the end of a box car. In loading open top cars with crude clay, ganister, or any bulky material, a locomotive crane, derrick or similar equipment is very efficient, when the location of the bed or deposit and of the switch track is convenient. (See also Conveyor, belt; Conveyor, brick; Truck, industrial; Carriers, gravity; and Loading machine.)

MANUFACTURERS (see catalog section):

American Equipment Co.
Freese, E. M. & Co.
Green, L. P.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Weller Manufacturing Co.

97—CAR, MINE, PIT, ETC.—A car consists of a box or body mounted on a frame with four wheels. It runs on a track and is used to transport material from one point to another. The gage of the track is usually about 24 or 36 ins. For mine or pit work, or for handling overburden, the cars are generally equipped with dump bodies (see also Car, dump). The bearings for cars of this type are made of cast iron, bored to fit the axle, and of babbitt. Great care must be exercised to keep dirt, etc., out of the bearings, and oil grooves must be provided so that the axles can be lubricated. There is seldom any chance to store oil or grease in bearings of this type. Some cars for this class of outdoor work are equipped with a bearing box which resembles a regular railroad car bearing, in fact, is a miniature thereof. The axle bears on a bronze plate which is held in place by the casting of the box. There is a reservoir underneath the axle for oiled waste, with which the axle lubricates itself. A hinged cap is provided to exclude the dirt. The advantage of this type of bearing is that it requires attention at intervals only. Cars used inside of a building for transporting clay, mud, etc., from a wet pan or other machine are often of the same type and have the same bearings as those for outdoor work. Both iron and wood are used for the frames and bodies of any of the cars described. The use of cars for hauling coal or ashes is not very common in clay products plants, but when they are used they are usually of the same type described for mine and pit cars. Any of the several types of bearings is satisfactory and the V-shaped dump body is generally found to be the most convenient. In some cases roller bearings are used on cars of this type.

MANUFACTURERS (see catalog section):

Eagle Iron Works.
Easton Car & Construction Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

Easton Car & Construction Co., 200 Fulton St., New York, N. Y. Easton Rocker Dump and clay handling cars, as well as dryer and kiln cars, can be furnished for meeting every car haulage requirement in the ceramic industry. Prices and specifications on cars and narrow-gage railway equipment gladly furnished upon request. See our page in the catalog section.

98—CAR MOVERS.—There are two general types of car movers, hand operated and power operated. The former is usually made to fit under the rear wheel of a car just back of the point where it is resting on the rail. There is a long handle attached, and by a system of levers the power exerted on the handle by one man is sufficient to move the car. This type is built for use on railroad cars, and also for dryer and other industrial cars. The power car movers are operated by a clutch on a shaft or by a capstan located at a fixed point. In moving railroad cars a wire cable is generally used and naturally the distance at which it can be operated is unlimited. In moving dryer cars a cable or chain can be used.

MANUFACTURERS (see catalog section):

Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Rodgers, L. E., Engineering Co.
Webster Mfg. Co.
Weller Manufacturing Co.

98A—CAR PULLER.—This refers especially to the power car movers for placing railroad cars. The reader is referred to the item Car movers.

MANUFACTURERS (see catalog section):

Link-Belt Company.
Weller Manufacturing Co.

98B—CAR PUSHERS.—This equipment is used for moving a string of cars thru a dryer or tunnel kiln. The main object to be sought is a steady slow movement at a uniform speed. In the case of a tunnel kiln, it is advisable to have the pusher adjustable so that any speed can be attained, the object being that the cars are moved forward at the same speed at which they are being filled. Take a kiln which is filled by a dry press, making 20,000 brick per day for six days, or 120,000 per week. As the kiln operates seven days and 24 hours per day, the pusher must operate at a speed sufficient to equal the week's output. The same proportion is necessary for a plant making ware other than brick.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Rodgers, L. E., Engineering Co.

98C—CARRIER BUCKET.—This refers especially to the conveyors and elevators in which the bucket is fastened to a chain or to two chains. The reader is therefore referred to Elevator or bucket conveyor; Conveyor, drag-plate and bucket; Conveyor, chain.

MANUFACTURER (see catalog section):
Link-Belt Company.

99—CARRIERS, GRAVITY.—Gravity carriers are used for transporting brick, etc., from the kiln to the packing room, railway car, motor truck, or stack. The usual type consists of a light framework, constructed in sections to make it portable and adjustable, and fitted with a series of rollers which form a runway for the moving material. The rollers operate on ball bearings to facilitate ease of movement. Very little slope is required, as the momentum gained by the use of ball bearings conveys the goods around corners and over irregular ground with surprising ease. It is generally advisable to supplement the gravity conveyor with a short belt elevator. The automatic features and the adjustability of the gravity carrier make it an especially valuable time and labor-saving unit.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Link-Belt Company.

CAR, TRANSFER, see Transfer car.

100—CAR UNLOADERS.—The unloaders that interest a clayworker chiefly are the ones to handle raw clay and coal. The same equipment will handle either commodity, or any bulky material of similar nature. There are two general types, one for unloading box cars, and the other for unloading open top cars. In unloading box cars, a scoop not over six feet wide is used. This scoop is hauled or pulled to the end of the car and then hauled to the doorway, by means of a wire rope, the material being dumped at this point. In unloading open cars, one method is to have a conveyor belt, which is adjustable, lay on top of the material to be unloaded. A man in the car feeds the material onto the belt, and the rest of the operation is automatic. Of course cranes are also used largely for unloading open top cars. In addition many plants have a trestle, by means of which a dump bottom car can be unloaded very easily, by throwing the proper levers, and allowing the material to drop onto the ground or into bins from which it is used or hauled. (See also Coal handling equipment.)

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Link-Belt Company.
Weller Manufacturing Co.

101—CAR WHEELS.—This item refers to the wheels on the many types of industrial cars used in a clay products plant. Very frequently the overburden is removed in cars. The raw clay that is to be used is generally transported from pit to factory in cars. Whenever a tunnel dryer is used, cars are the medium of transportation. Coal and ashes are sometimes hauled in cars, and other uses are found at times. It can readily be seen that there must be a type of wheel for each use, so that the minimum of metal is used for the maximum of efficiency. Some of the uses are quite severe. Wheels for cars of this type are made of cast iron, cast steel, manganese steel and sometimes partly of pressed or sheet steel. Cast iron wheels always have the rim made of chilled cast iron or of cast steel, as most of the wear occurs at that place. Wheels for this class of service are usually shrunk on the axle or fastened with a set screw, and there is generally a shoulder on the axle against which the wheel bears to prevent it from sliding on the axle. This type of wheel is used on any car that runs on a track. When the wheel turns on an axle, roller bearings or ball bearings are usually provided, and if the axle turns with the wheel the roller or ball bearings are usually placed in the box in which the axle turns. Other types of bearings are described in item Car, mine, pit, etc.

MANUFACTURERS (see catalog section):
Eagle Iron Works.
Easton Car & Construction Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

102—CAR WRENCH.—These are tools or instruments by means of which dump bottom coal cars, etc., are unloaded. A dump bottom car usually is arranged to dump its load when a certain rod or a certain set of rods is released. These wrenches are intended to release this load surely and quickly. A poor wrench which delays the dumping of a car not only reduces output and increases costs but spoils the enthusiasm of the men and they will not take nearly as much care of the material as they will when the car is dumped promptly and efficiently.

103—CASTING.—In the pottery industry, casting consists of pouring a clay-slip into a plaster mold which absorbs some of the water, and causes a thin layer of clay to adhere to the inner surface of the mold. To produce this character of slip with less water some alkaline salt is added to the mixture. When the layer on the inner surface of the mold is of the required thickness, the mold is inverted and the remaining slip poured out. After a few hours the mold is removed and the seams left by its junctions are removed by "finishing." Handles or other necessary additions are attached by using slip.

Casting is extensively used in making thin porcelain ornaments, whiteware objects, etc. It is also used for making belleek. The process is entirely dependent on the absorbent nature of the plaster mold, which may be of endless variety as regards shape. There is likewise practically no limit to the modeled ornament that may be incorporated with the shape, provided it is not "undercut" and will "draw" from the mold.

104—CASTINGS, METAL.—Practically all of the machinery and equipment around the plant is composed largely of castings. A casting is any piece that is formed by pouring molten metal into a mold of sand which has been made the same shape and size as a "pattern." These castings are made of different mixes of iron and steel. The most usual is an ordinary grey iron casting. Where one surface will have more wear than the rest, the sand in that part of the mold is replaced by a piece of iron called a "chill." As a result that surface of the casting chills quickly and has a harder surface. There are also malleable castings, in which process the castings are given a very thoro annealing treatment, which increases their resistance to breakage. This process is especially suited to small castings. Steel castings, made from molten steel instead of molten iron, are still stronger, and the hardest casting known commercially is a manganese steel casting. (See Manganese Steel.)

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Eagle Iron Works.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Rodgers, L. E., Engineering Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

105—CATERPILLAR TRACTION.—This is the term used to indicate the improved method of moving a locomotive crane, steam or electric shovel or other digging or ditching machine over the ground. In the positions usually occupied by the wheels of a traction drive, gears of about 18 ins. diameter with very large pitch are placed. The teeth of these gears engage in openings or offsets in castings which form part of the chain or caterpillar. The caterpillar really consists of a series of flexibly joined links, which hold iron bound planks, the whole forming a broad chain, which is endless and fits around two of the gear wheels. There are always two caterpillars to a machine. The moving is accomplished by the gears pulling the caterpillar around. This equipment enables a machine to turn around almost in its own space if one caterpillar goes forward and the other backward. The big advantage gained in the use of a caterpillar traction is the fact that the machine will be able to go almost anywhere without danger of miring in the mud. It can go up and down steeper inclines than is possible with any other type of traction. The tanks used in the late war in Europe were equipped with caterpillar traction, and much of their success is due to this fact. (See also Shovel, power; Crane; Shovel, electric; Shovel, steam.)

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

CAT OIL, see Oil, cat.

106—C. C. WARE.—An abbreviation for cream-colored ware; a common variety of ware made from low-grade china clays, being considered the cheapest quality of white pottery product. As the name indicates, it was originally of a creamy tint, but in recent years competition has caused such an improvement in color that it is now equal to what was formerly the next better grade of white earthenware.

107—CEMENT, BUILDING.—There are two classes of building cement, namely, Portland cement and Hydraulic cement. The former is a manufactured cement, suited for use anywhere that water is not present. The latter is usually a natural cement and is especially suited for work under water as it sets better in that condition. Both are very well fitted for any foundation work either of concrete or brick. All brick walls are stronger if the mortar contains cement, and cement used on top of kiln crowns aids materially in keeping out water. Cement wheelroads are very good around the yard and in storage sheds. (See also Concrete and Foundations.)

108—CEMENT, HIGH TEMPERATURE.—High temperature cement is a mixture of certain ingredients which withstand high temperatures and at the same time have high bonding or cementing qualities. It is used in place of fire clay as a mortar in laying up fire brick. Many causes for the poor service secured from fire brick can be traced directly to the fact that the bonding clay used was not as good in quality as the clay of which the brick were made. High temperature cement is made in several grades to stand as high a heat as the best fire brick, and it has the additional advantage of having better binding qualities than fire clay. It can be used to very good advantage on the inside wall of a boiler setting or on the inside of the walls, flues, floor and stack of a kiln.

There are similar materials which are ground coarse, and therefore cannot replace fire clay in laying up brickwork. They are especially suited for patching up the cracks or worn parts of any fire brick work.

MANUFACTURER (see catalog section):
Celite Products Co.

109—CEMENT, INSULATING.—Insulating cements are plastic cements that are especially suited to retard the passage and radiation of heat. Some of them are made of the same material as insulating brick, and there are also others made of other materials. In addition to being used as a mortar for insulating brick, they are especially adapted to patching cracks as they appear in boiler settings, kiln walls, and kiln crowns, thus preventing leakage and loss. Kieselguhr is the foundation of most of these cements. Asbestos is also used extensively, as well as magnesia, cork, etc.

MANUFACTURER (see catalog section):
Celite Products Co.

110—CEMENT, WATERPROOFING.—One of the great troubles at a clay plant when there are underground flues, elevator pits, etc., is the presence of water in those underground places. Elevator pits should be protected by one of the waterproof cements. These can be mixed with the cement when the pit is built or a coating can be put on after the concrete has set. This coating generally is made of black plastic material like pitch. Some of the companies putting waterproofing of this kind in place, guarantee that it will successfully keep out the water and moisture for a definite length of time, and put up a bond to that effect. Water in an elevator pit is a constant source of cost and trouble, to say nothing of the curtailed production. The best way to waterproof kiln flues is to install an efficient drainage system, but in addition the use of a high temperature cement put on as a wash will help. The ground beneath a dryer should be kept dry, and the method described above for an elevator pit will work satisfactorily beneath a dryer.

MANUFACTURER (see catalog section):
Celite Products Co.

110A—CENTIGRADE.—The thermometer scale which uses the temperature of freezing water (on the Fahrenheit scale equal to 32 deg.) as 0 deg., and the temperature of boiling water (on the Fahrenheit scale equal to 212 deg.) as 100 deg.

The reading on the Centigrade scale is equal to the reading on the Fahrenheit scale minus 32 and then multiplied by 5/9. Thus 2000 deg. F.—32× 5/9=1093 deg. C. C. is used as the abbreviation for Centigrade and F. for Fahrenheit.

CENTRIFUGAL PUMPS, see Pump, centrifugal.

111—CERAMICS; A BRIEF HISTORY OF ITS ORIGIN AND DEVELOPMENT AS AN INDUSTRY AND AN ART.—The story of clayworking leads back into the remote antiquity, thence forward thru the rise and fall of many peoples and empires into the myriad activities of the present for which the almost innumerable classes of clay ware are manufactured. For practical purposes, a brief history of this development falls into two parts, one dealing with brick, the other with pottery.

The Story of Brick.

In some archaeological borings in Egypt, debris of fired brick were struck at a depth of 25 to 30 ft. below the level of the valley of the Nile, and this discovery, based upon the progressive elevation of the soil from the overflow, suggests that these beds contain the debris of brick deposited there 10,000 years ago. The earliest recorded date in history is found on a brick tablet of the time of Sargon of Akkad, 3800 B. C., founder of the Chaldean Empire. It was, of course, but natural that the dwellers along the great Euphrates and Tigris rivers should note how the sun baked and irregularly cracked clay blocks, and to find them, after crude shaping, very suitable for building the walls of a hut.

Babylonia; Origin of the Trade Mark.

In the early dawn of recorded history, over 2000 B. C., the Chaldeans had already acquired and practiced the art of making hard, durable, sun-baked adobe brick. When they learned to burn the brick is not known, altho they practiced burning at the time the tower of Babel was built. Before Nebuchadnezzar's reign as king (604-562 B. C.) of Babylonia, men had learned and practiced both the art of hard-burning brick and of beautifully enameling them. Tradition holds that the great fish-god Oannes himself taught the Babylonians this art; how highly they prized it is witnessed in the patronage of the king who stamped the brick with his name. This is probably the aristocratic and venerable origin of placing a trade mark on a manufactured product.

Herodotus, the Greek historian of the fifth century B. C., described the wonders of Babylon, which included great walls, wonderful temples, and marvelous hanging gardens, all of which Nebuchadnezzar had built from brick to please his Median queen.

The Assyrians, who derived their civilization from the Babylonians, perpetuated the brick tradition, and the remains of their vast palaces of brick, as well as of great brick libraries—i. e., books made up of inscribed burned clay tablets, form one of the most interesting and valuable links in recorded history.

Egypt.

It is likely that the art of brick making spread, in ancient times, eastward from the Mesopotamian plains to Persia, India and China, and westward to Egypt, Asia Minor, Greece and Rome. In Egypt, which rivals Babylonia in the antiquity of its civilization, the most ancient brick remains do not go back of the fifteenth or sixteenth century B. C.; these are represented in two pyramids made of sun-dried brick found at Dashur, a few miles south of Cairo. It has been suggested that it may have been here that Herodotus saw the singular inscription which his Egyptian guide thus interpreted for him: "Disparage me not by comparing me with pyramids built of stone. I am as much superior to them as Ammon is to the rest of the deities. I am constructed of brick made from mud which adhered to the ends of poles and was drawn from the bottom of the lake." Thus, from ancient Egypt is derived a pretty good line of brick advertising. In fact, the Egyptians apparently prized the brick industry as highly as their Babylonian predecessors, for they ascribed the art to Nun, the oldest and wisest of their gods, and Pharaoh monopolized the business by having his name stamped on the product. Egyptian brick making, however, never reached the degree of perfection attained by the Babylonians.

Europe.

Europe naturally acquired the art of making and using brick from the Romans, who left splendid and extensive remains of brickwork in nearly every part of their wide domain. The Baths of Caraccalla, the Basilica of Constantine at Rome, and the spectacular dome of St. Sophia's at Byzantium, or Constantinople, are striking examples of Roman practice in handling brick. After the Barbarian invasions had subsided and the Church had succeeded in introducing some semblance of order into European society, architecture, especially with the thrilling times of the Crusades, began a brilliant career in the so-called Romanesque and Gothic periods. Here brick found its useful plane in art combined with service, and in countries where clay was abundant, as in northern Italy, southern France, northern Germany, and the Low Countries, extensive brick building was carried on. In Spain, the Moors also revealed their mastery of the craft in such structures as the Alhambra at Granada, and the Mosque, now Cathedral, of Cordova. During the great Gothic period, from the thirteenth to the fifteenth centuries, brick entered upon its palmy days, and was freely and fearlessly used with most effective and artistic results, notably in northern Europe where the wealthy and growing burgher cities used brick to build many a splendid city gate, church, town or guild hall, and mansion.

England.

In England, brick were first made by the Romans, during their three and a half centuries of occupancy. The home industry, however, does not appear until the thirteenth century, and did not reach perfection until the time of Henry (1509-1547), when it was probably accomplished under Flemish influence. In 1666, the great fire transformed London from a wooden to a brick town and gave a great spur to the brick industry. It remained, however, for the days of Queen Anne and the Georges, in the eighteenth century, to introduce a vogue for brick that almost eradicated the demand for other kinds of materials, and resulted in the erection of those fine country houses which, scattered thruout England today, are so representative of substantial comfort and dignity. In modern construction, English builders have maintained a fine sense of the architectural values in sound and beautiful brickwork.

America.

America, too, has its brick antiquities. The Spanish Conquistadores discovered crude but excellent adobe brickwork in Peru and Mexico, and further developed it in their own settlements. In North America, the first brick houses were built of material brought from Holland or England, altho in Virginia, as early as 1611, and in Massachusetts, as early as 1629, the domestic industry was established. Naturally, European, especially English, practice was closely followed. The Colonial days produced fine examples of brick architecture from New England to Virginia. In the nineteenth century, up to 1880, American brick building was largely confined to the use of common brick for average construction or for backing stone-faced walls. Since then, a growing individual and national taste has demanded and secured artistic effects in the brick wall by the use of specially manufactured face brick which are now produced in a myriad variety of beautiful color tones and textures, and which have been used by leading architects to achieve much that is distinctive in building design and construction.

Progress in America.

The American manufacturer has outstripped all foreign contemporaries in the manufacture of face brick, so that the range of color tones and textures he now offers is such that the prospective builder is capable of incorporating in the exterior wall surface an enduring color scheme of monochrome uniformity, or polychrome blending, as his taste may dictate. The whole sweep of color, in smooth or rough textures, is available, from the pure, severe tones of pearl grays or creams, thru buff, golden, and bronze tints to a descending scale of reds, down to purples, maroons, and even gun metal blacks.

The Story of Pottery.

To all intents and purposes, modern knowledge of pottery other than brick begins with the era of burned ware, since any unburned ware must have perished long ago. Unburned brick survived partly because of its mass and partly because its use was confined to a dry climate. Closely allied to brick are the wall tiles which were brought to sub-perfection in Mohammedan lands. It is quite likely that the use of the richly glazed decorations which will be discussed later originated in these tiles.

In the region of the Nile, according to Mariette Bey, there are found in tombs of the Memphite period (5000-3000 B. C.) vases of terra cotta which were intended to contain provisions for the deceased. Also, on the walls of the tombs of the Beni-Hassan, pictures have been discovered portraying scenes from the life of Egyptian potters, modelling vases and firing them in an oven, at a time corresponding to the Theban Period (3000-1700 B. C.). To this period is attributed the discovery of glazes and the manufacture of the first pieces of earthenware found in the pyramid of Saggarah. Between 1700 B. C. and 500 B. C. the art of earthenware manufacture attained rare perfection, as is illustrated by the decorations of the temple of Tell-el-Yadouai built by Rameses III.

It is uncertain as to whether the Chaldeans and Assyrians had borrowed their processes from the Egyptians, or whether they discovered them in actual practice, but it is known they discontinued the long-accustomed use of crude brick and erected the palaces of Croesus at Sardis, of Mausolus at Halicarnassus, and of Attalus at Tralles of beautiful, red, fired brick. Tombs of a single piece of ware, or formed by two pieces cemented together, attest the skill of Chaldean and Assyrian potters, even in that remote day. It is possible that the Indian races learned the manufacture of fired bodies and glazes from the Assyrians and Chaldeans; in the Vedic hymns mention is made of pottery. The Persians, successors to the Assyrians, carried the manufacture of monumental earthenware to a high degree of perfection.

In Asia, the Chinese claim the first pieces of pottery were made by one Kouen-Ou between 2698-2599 B. C.; but the great contribution of the Chinese, that of permeable pottery (stoneware and china), is of more recent origin, being first mentioned between 175-151 B. C.

The aborigines of America manufactured remarkable terra cottas, and in certain sections of Mexico and Central America, this manufacture undoubtedly goes farther back than 1000 B. C.

Thus, terra cotta was invented by three different people — Egyptians, Chinese, and Mexicans (Aztecs)—in the beginning of their respective civilizations, and at periods too remote for accurate dates to be assigned to them.

Primitive Potters Were Women.

The primitive potter shaped her wares (the work was almost invariably done by women) by hand, sometimes without the aid of any supporting form, sometimes with a wicker shape. The pieces were made with thick walls for ease of working, and later reduced to the desired lightness by shaving or scraping the nearly dry clay. The burning was done in an open fire, the pieces being filled with bark or chips of dry wood and placed upside down amid the fuel. Wood was then heaped on them, the firing kept up until a mass of glowing charcoal covered the wares. The remarkable fire-flashed colors thus produced were the result of accident, since it is not likely that the subtle, delicately shaded tints conveyed any pleasure to the untutored mind. In time, the open fire gave place to the enclosed fire, altho the wares were still exposed to the flame. In his paper, "The History of the Ceramic Arts," Charles F. Binns presents the suggestion that the technology of all the early forms of pottery was founded upon what chemists know as a reducing fire, produced (in the absence of better fuel) by the use of refuse vegetable matter, stubble, brush and animal waste as fuel, thus robbing the iron oxide in the clay of a part of its oxygen, and producing a ware that varied in color from black to gray.

Old Roman and Other Practices.

The beautiful black coloring of early Greek terra cotta is the black oxide of iron which can be maintained only by a properly applied reducing fire. The black or gray ware of the Romans was also burned in a kiln into which sufficient air for oxidation could not enter. The Romans, in their conquests of other lands, carried the potters' art with them and introduced it in occupied territory; but as their power waned the art declined and almost vanished. The Gauls and Saxons possessed nothing better than barbaric methods in industry, including the manufacture of clay wares. No notable advance was recorded until the approach of the Middle Ages; then, either by alchemy or magic, the ideal became not a black but a white ware.

In Mesopotamia, Syria and Persia, technique was concentrated toward producing a pure white pottery. The method was ingenious but imperfect. The bodies were still made of dark colored clay and the white surface obtained by using a veneer of an infusible substance consisting largely of quartz flour. Upon this there was placed a transparent, brilliant glaze prepared from lime, soda and quartz—a composition similar to the common form of glass. A German investigator has shown that this technique was rendered possible by the same smoky (reducing) fire explained above, as the fuels used did not contain sufficient sulphur to affect the brilliance of the glaze.

What was it, however, that created the furore for white pottery instead of black?

Chinese Practice.

In the distant empire of China the production of clay wares had proceeded from prehistoric times (see dates above) in a manner similar to that which obtained in other lands; but Chinese civilization had progressed rapidly. Its beginnings were rooted in the dim and distant past; locked within itself for centuries, Chinese records are said to date back to 2000 B. C.; and even if this be regarded as tradition and conjecture, the dynasty of Han (200 B. C.-200 A. D.) is established history. At this early date, Chinese potters were producing wares which are still the marvels of connoisseurs; and in the Great Ming dynasty, which began in 1368, the finest porcelain ever seen was made.

After the first crusade in the eleventh century, the intercourse of nations slowly increased until the famous traveler, Marco Polo, revealed the wonders of the far East to Europe and the near East. Thus, the potters of Mesopotamia saw for the first time Chinese whitewares. They had long since been versed in the mysteries of clay and fire, but familiar only with wares of dark color, and it is not surprising that their ideal of black ware fell before the finer ideal of pure white.

There were three vital contributing factors to the development of Chinese whiteware—the high standard of civilization, the patronage of the mandarin and even of the emperor, and the discovery of a snow-white clay which was found to be associated with a white granite rock. With the characteristic patience of the East, these materials were blended so as to produce a plastic paste. But to bring the latter to a sufficient density a severe fire, reaching a temperature (as we now know) of over 1,400 deg. C. (2,192 deg. F.), was used, so that the white rock mixed with wood ashes could be melted to a glaze, or the same rock mixed with white clay would produce a pure translucent ware. The same reducing fire, normal to the Eastern potter, was retained, but the Chinese used wood exclusively as a fuel. The ashes of this wood were saved and mixed in the glaze, care again being taken to specify for fuel only such wood as produced the right kind of ashes.

In the absence of white clay, Persian and Syrian potters were unable to duplicate the Chinese white body, and directed their efforts towards perfecting the white coating already described. They succeeded in producing a rare standard of slip-covered ware which to this day is characteristic of the East. Further evidence of Chinese inspiration is found in the blue decorations they used which often followed Chinese motifs. From that date forward, the world adopted whitewares as standard and still continues to esteem Chinese porcelain in particular as a criterion.

Mohammedan Slip-Ware.

Following the fortunes of Eastern veneered or slip-coated ware is in itself an interesting adventure. The term "slip" is used technically to designate a clay or clay mixture rendered fluid by water. Where this material is used to cover a clay body, the French term "engobe" is often employed, and so the class of pottery now considered got its name, "Oriental Engobe Ware." It is unique, first, because of its beauty, and, second, because it possesses individual characteristics evolved from the special processes of manufacture. The ground is usually a pearly white or light gray, tho occasionally a piece of delicate pink color is found. The decoration is outlined in black, typical colors being the deep blue of cobalt, the turquoise of copper, and the purple of manganese. There is occasionally found also a rich iron red. These colors depend for their peculiar quality upon the nature of the glaze which covers them; this consists essentially of a silicate of lime and soda and differs radically from glazes of the present day.

The manufacture of this ware was carried on in lands under Mohammedan rule, and thus may be classed with Damascened steel and embossed leather. It began in Mesopotamia, or in the general region of which the city of Bagdad may be considered the center, the knowledge of the art spreading thruout Persia and Syria, thence along the northern coast of Africa to Morocco. The beginning of the thirteenth century saw the establishment, after repeated invasions, of Moorish influence in Spain.

Development of Tin and Lead Glazes.

One result of this was the development of the decorative art known as Hispano Moresque of which the palace of the Alhambra at Granada, is one of the best examples. The Moors brought with them their knowledge of pottery making, but before long a new idea was born and a different fabric created. From some unknown source sprung the knowledge that a glassy glaze could be made opaque by the admixture of oxide of tin, and at the same time it was revealed that oxide of lead would make a more brilliant glaze than had hitherto been made with soda. The facts were revolutionary. There was then developed a brilliant fusible, opaque glaze which enabled the potters to make a white surfaced ware without the use of an undercoating or slip; and it was also found that glaze made from lead was much more easily fused in the kilns than the former glaze had been.

This gave birth to the tin enameled or stanniferous wares of Spain upon which the well-known golden and lustrous decorations were perfected. Perhaps because the island of Majorca lay in the line of traffic along the northern shore of the Mediterranean sea, or perhaps because some of the ware was made there, the pottery was known as the ware of Majorca, and this became, in Italian, Majolica.

The Italian Influence.

The artists and critics of Italy, then in the first enthusiasms of the Artistic Renaissance, quickly seized upon this new means of expression. Lucca della Robbia, architect and sculptor, covered his clay figures with white enamel. Giorgia Andreoli, of Gubbi, produced a magnificent red luster. The cities of Urbino, Siena, Castel Durante, Faenza and many others each contributed some special modifications of style. Numerous examples of their products, some fine, some inferior, are found in all modern museums. The methods of Italian potters were described in detail in a history of the art written in 1548 by a certain Piccolpasso.

From the last quarter of the fifteenth century to the end of the sixteenth, pottery manufacture underwent a gradual change in technique. The facility with which lead compounds can be used is common knowledge. The Italians fell into the lines of easiest resistance; little by little the lead was added (to meet lower kiln temperatures) until the fusible glaze obtained dissolved the best of the colors. The palette was denuded of one tint after another until only blue and yellow remain. These colors, being able to withstand the solvent action of the lead, held their position.

Delft Ware of Holland.

This was the condition of the Italian product when knowledge of the art spread northward to Holland and the Netherlands. Simultaneously, a new Chinese influence made its appearance, thru the medium of enterprising Dutch merchants who brought to Europe new supplies of Chinese porcelain. This was mostly decorated with cobalt blue, which is capable of withstanding the intense porcelain fire. The potters of the town of Delft, combining this fact with their knowledge of Italian enameled ware, produced the blue pottery for which Delft became famous. The Delft potters also formed the first trade guild, known as the Guild of St. Luke, which controlled pottery production in Delft and probably contributed to the quality of the wares.

Origin of German Wares.

It is now necessary to digress for a moment from the field of enameled pottery to discuss a class of wares then forming a large part of German production. This pottery resulted from the unrecorded discovery sometime in the fifteenth century, that a certain type of clay can be glazed with the vapor of common salt. This clay was generally refractory or capable of withstanding the action of a high temperature, and, in modern practice, would be known as a second-grade fire clay. The pottery was made in three colors, brown, gray, and a pearly white, and these colors were due to variations in the clay itself. The forms were shaped on the wheel, decorated with modeling and applied embossment and set in the kilns in such a way that each piece was exposed directly to the gases of the fire. When the kiln containing pieces of ware reached a certain temperature, salt was thrown upon the fire. The heat vaporized the salt, and the vapor passed in amongst and circulated around the pottery. Salt consists of sodium and chlorine. The chlorine passes away with the smoke but the sodium condenses on the glowing clay in the form of minute drops and produces the interesting orange-skin texture which is the distinguishing feature of salt-glazed pottery.

The city of Cologne was famed for its production of salt-glazed stoneware, and varieties originated in other places, the name of the ware generally being derived from the point of shipment, hence the old terms Gres de Flandres or Gres Flamande. Other familiar types were the well-known

Graybeard, Bartmann and Bellarmine jugs, etc.

Origin of French Faience.

Resuming the story of enameled pottery the trail leads, at the opening of the seventeenth century, into France, where the rulers of a number of independent dukedoms or electorates fostered the production of pottery. The Duc de Nivernais brought an experienced worker in enameled wares from Faenza, Italy, and from this arose the name "faience" as the French equivalent of Majolica. In 1644 the art was taken to the old Norman city of Rouen, which became an important center of faience manufacture. In 1702 the industry was given great impetus by the action of King Louis XIV, who, in order to continue his wars, disposed of his gold plate and replaced it with faience. His action was followed by a similar furore among the nobles for faience ware. The potters took advantage of the condition to produce some excellent services. The industry was also carried on in many other centers, such as Moustiers, Strassburg, Marseilles and Dijon.

Two enterprises of special character marked the activity of French potters in the sixteenth century.

The earlier of these was begun in 1524 by Helene de Hangest, a skillful artist, who contrived, with the assistance of two men, Bernart and Carpentier, to produce the faience d'Orion generally known as Henry Deux ware. The pieces were constructed of a cream colored clay, and in form they partook almost of an architectural character. The principle feature, however, lay in the decoration, which consisted of an intricate series of interlacing lines and bands which were sunk in the light colored clay and then filled in with dark clay. The whole was covered with a transparent colorless glaze. The style and method were unique and it has been thought that the idea was based on the tooling of book covers, since it is known Bernart was library guardian at the Chateau d'Orion, Mme. Hangest's home near Thouars. Only 57 pieces of this most exquisite pottery exist; one in a private Russian collection, the remainder divided between French and English national museums.

The second enterprise was that of Bernard Palissy, who wrote in 1542 that he had been engaged for more than 25 years in an effort to duplicate a cup of surpassing beauty that he had once seen. After much speculation it is now generally thought that Palissy's inspiration was actually a piece of Chinese porcelain. Obviously, lacking the native materials that are in a large measure responsible for the excellence of Chinese porcelain, he failed in his efforts to create the white enamel of his ideal, but he did succeed in producing pottery of such excellence as had not appeared up to that time and which has not been excelled to this day. His most important works were modeled in crude clay, largely in imitation of natural objects, and the forms were covered with glazes of clear pellucid colors, as of pebbles seen at the bottom of a brook.

Early English Pottery.

The early British had some knowledge of clay working and examples of their funeral urns are to be seen in all museums. The Romans improved the art but with the Saxon conquest most of this was swept away. The first traces of its revival lead back to about the fourteenth century. Two jugs were found several years ago at the bottom of a well at Chichester and assigned to this date. From the fourteenth to the seventeenth century pottery was scarcely more than a craft of the peasantry. By degrees small communities of potters were formed in localities where suitable clay was available. In this manner were created the potteries of Staffordshire. Clays of rather crude quality were, and remain, abundant in the northern part of the country. The primary fuel was wood, but the locality also contains a good supply of fine coal, now used exclusively.

The Staffordshire potters revived the process of making slip decorated ware, which had first been introduced in Roman times but had long since fallen into disuse. The ware became very popular in the seventeenth century. The pieces were shaped on the wheel and the decoration laid on in the fluid clay called slip. Sometimes a dark ornament was laid on a light background, sometimes the reverse was accomplished. A liberal use was made of simple arrangements of dots, the nature of the technique naturally arising from the character of material available. The slip was allowed to trickle from the spout of a vessel similar to an engineer's oil can, the method permitting a great freedom in the disposition of the lines. A fusible lead glaze supplied a brilliant finish to the pieces. These early potters exercised a certain genius in developing the decorative possibilities of colored clays and colored glazes. They produced the mottled wares known as agate and tortoise shell, and are credited with the manufacture of the most natural clay ware of all time.

About the year 1688 two brothers, named Elers, came from Holland and introduced many refinements of process and taste. These brothers were as secretive as potters always have held the reputation for being, and tradition asserts that they were wont to engage helpers of low mentality, in order to more safely guard their secrets. Report has it that two skilled English potters, by pretending to be weak minded, secured employment with them and later used the valuable information they secured to their own advantage.

The Elers appear to have brought to England a knowledge of German salt-glazing, altho some authorities contend these processes were anticipated by John Dwight, of Fullman, who was granted a patent in 1671 "for having discovered the misterie and inventions of Cologne ware." In either event, Staffordshire workmen were making quantities of salt-glazed pottery by 1720, and, later, with rare artistic success.

Josiah Wedgwood, the most celebrated English ceramist, was the author of the next great improvement. He developed the factory system of division of labor. The earlier potters had carried out all details of their work individually. Wedgwood so manipulated the processes of manufacture that each piece passed thru the hands of skilled designers, skilled wheel men, skilled decorators, etc., thus bringing each successive step of manufacture to perfection. The innovation was a serious loss from the viewpoint of the craftsmen, but it laid the foundation for supremacy in pottery production which England still holds. Wedgwood was a tireless investigator, spent money freely in securing skilled help, and his work stands unrivalled to the present day. He enjoyed the patronage of Queen Charlotte, hence the name "Queen's ware," which designated one of the many superior services which he created.

The New Era Approaches.

There only remains the story of porcelain to relate. In this respect, the influence of Chinese ware has been noted, but the only result was a series of imitations. The slip-coated wares of the East and the enameled wares of Spain, Italy, Holland and France were made white only by surface treatment. They lacked the substance of porcelain; they were neither dense, sonorous nor translucent. However, documentary evidence points to the making of porcelain, probably as an experiment, at Venice in 1519 and in Ferrara in 1575, but specimens of these wares are unknown. At Florence, about 1590, the renowned Medici porcelain was produced. This is now extremely rare; there is no example in this country and England possesses but six pieces. France has evidence of but one piece of porcelain, made at one of the faience manufactories at Rouen in 1690. The first real factory of soft porcelain was established at St. Cloud in 1695.

The term "soft porcelain" should be explained. It has been recorded that the inspiration for European and Asiatic whitewares came from the discovery of Chinese porcelain, but the production of the latter was dependent upon the possession of a special clay and its associated rock (entirely peculiar to China) and the use of an especially intense fire. French porcelain was in reality an evolution from fine faience, and was produced at a temperature used for cruder ware. The body or paste was composed of a mixture of fusible and infusible ingredients, such as potash, alum and sand, mixed together and agglomerated by firing. The mass was then reduced to a fine flour by grinding, and a small amount of plastic clay added in order to make a workable paste. After being shaped the pieces were subjected to a temperature just high enough to develop density and translucency. Too high a temperature would cause softening or even melt the ware to a glassy mass. For this reason, also because a very fusible glaze is used, the ware became known as soft porcelain or pate tendre; it is thus merely an imitation of true or hard porcelain. Nevertheless, so skillful were French potters and decorators that magnificent pieces were eventually made.

The factory of St. Cloud was followed by the establishment of many others in other French provinces, due to the encouragement of the various arts by the ruling dukes and princes. It became a profitable trade to profess ability to make porcelain. Anyone with sufficient "bluff" could secure lucrative employment until his failure was detected; then he had only to pass on to the next prince, repeat his story, and go to work until his shortcomings were again discovered.

These abortive enterprises were punctuated, however, by the successful establishment of a venture at Vincennes, about 1750. Within three years, the French king acquired a third interest in this plant, and the title of Royal Manufactory was bestowed. In 1756, the plant was moved to Sevres, and the king became sole owner. The soft porcelain of Sevres is so well known that its history may be passed over, except to say that in 1804 its manufacture was abandoned, and the plant has since worked hard porcelain exclusively.

Hard Porcelain Manufacture.

Germany is accredited with starting the manufacture of hard porcelain in Europe. The king of Saxony had made a collection of Chinese porcelains, and many attempts were made to produce a similar ware. In 1710 porcelain earth or kaolin was discovered. It is related that kaolin was first sold as a hair powder and in some manner brought to the attention of a chemist, named Bottger. Being already acquainted with the composition of Chinese wares, this man was now able to manufacture a true hard paste, later known as Meissen or Dresden porcelain. An endeavor was made to keep the composition a secret, but it was divulged by a workman, with the subsequent springing up of many factories, a few of which were successful.

Holland, Russia, Italy, Spain and Portugal all contributed to the manufacture of porcelain.

English Bone China.

The first porcelain factory was founded at Bow, near London, in 1744. The composition of the first paste was based upon the soft porcelain of France, but there soon came into use a certain substance which has since characterized all English porcelain or chinaware—that is, phosphate of calcium in the form of burned bones. It is this ingredient that has caused English china to be known in this country as bone china. In 1748 another factory was built at Chelsea; and, later, one at Derby. The Worcester works, which has maintained an unbroken existence, was erected in 1751.

During the nineteenth century many new enterprises were undertaken in Europe and America, due to an increased appreciation of all forms of potters' arts and to the increasingly diversified demand; but, as arts, time has not mellowed them sufficiently to assign them a definite place in epochs of clayworking history.

112—CERAMIC SCHOOLS.—In late years the necessity of an engineering education along ceramic lines has led to the establishment of schools and colleges which teach the theory and practice of every operation around a clay products plant. The course lasts four years and the successful graduates receive a degree in Ceramic Engineering. The improvements and benefits that have attended the participation of these graduates in the operation of the industry far more than justify these courses. The attendance is steadily increasing, and the principal trouble is to obtain the funds that are necessary to put up the buildings and buy the equipment that is required. Some of these colleges have a special two year course for students that have studied general engineering and at times there are special courses that last only a few days or weeks, intended for practical men in the industry who cannot devote more time to attendance. They obtain much valuable instruction, however, that assists them in whatever work they are doing.

Following is a list of the ceramic colleges in the United States: University of Illinois, Urbana, Ill.; Iowa State College, Ames, Ia.; New York State School of Clay-Working and Ceramics, Alfred, N. Y.; Ohio State University, Columbus, Ohio; Rutgers College, New Brunswick, N. J.

113—CHAIN, AUTOMOBILE AND TRUCK, NON-SKID.—These chains are made in exact lengths to place on a wheel of an automobile or truck whenever the machine drives onto a wet slippery street or road, or into any mud or soft dirt. The object in the first case is to provide enough traction to prevent skidding or slipping on the wet pavement, and in the second case to provide enough traction or resistance to the mud or soft earth to enable the wheel to revolve without any difficulty and pull the machine out of the danger. For automobiles these chains are usually made to fit all around the wheel with short pieces of chains crossing the wheel at intervals. For trucks, the chains are usually short, to fasten around the wheel at one point and to fit around one spoke.

MANUFACTURER (see catalog section):
Link-Belt Company.

114—CHAIN BLOCK.—A chain block is a portable hoisting device which enables one man to raise and lower very heavy loads. One of its most useful features is the ability to sustain the load at any point. It is operated by pulling a chain, and the energy or power is transmitted to the chain holding the load by means of wheels that engage the chain and in some types by means of gearing in addition. A differential chain block is suited for loads from one-half ton to three tons. A duplex worm-geared chain block is suited for loads from one-half ton to ten tons. A triplex spur-geared chain block is suited to loads from one-half ton to 20 tons. The triplex works slower on a given load of, say, three tons than does the duplex, and the duplex works slower than the differential. For this reason the capacity is not the only item to consider in purchasing a chain block. The many pieces of heavy machinery found around a clay products plant make it imperative that chain blocks be used and in most cases several sizes are found advantageous. Machinery can be placed in position easier, more accurately, and with more safety. The same holds true of making repairs. A chain block will pay for itself in a very short time. One of the uses not found as often as it should be found is in raising and lowering dampers of continuous and intermittent downdraft kilns. Too often a damper is set by a rod supported by bricks or a block of wood. This is inaccurate and the fireman has a temptation to leave it undisturbed longer than he should. (See Dampers.)

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

CHAIN CONVEYOR, see Conveyor, chain.

115—CHAIN DRIVE, SPROCKET.—A chain consists of a series of malleable iron links, which are joined together by flexible joints. A chain is used in many places to drive a machine or part of a machine, where the distance between shafts is small or where it is hard to keep a belt in place. A chain drives over a sprocket wheel instead of using a pulley like a belt. The power delivered by a chain is positive, as there is no slippage and friction of the shafts is reduced because the chain does not have to be as tight as a belt. Elevators, represses, dryers, etc. are some of the places where they are found. (See also Belt, Silent-Chain.)

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
International Clay Machinery Co.
Link-Belt Company.
Weller Manufacturing Co.

116—CHAIN, LOAD.—A load chain consists of a series of links or rings, connected or fitted into one another for holding a load. The links or rings are made of bar metal, cut and made into the proper shape and welded. The quality of the iron or steel in the bar from which the chain is made and the size of the bar are factors that determine the strength of the chain. Of course the welds must be strong enough to hold the full capacity of the chain. Chains of this type are used in chain blocks, and short pieces are used around beams and rafters of buildings and also around machinery for fastening the upper and lower hooks of the chain blocks. The main use, however, around a clay products plant is in steam and electric shovels and other digging and hoisting machinery, when the work to be done or the load to be carried is too great for practical use of a wire rope or steel cable. All of the heavy duty type of shovels use a chain for hoisting the dipper.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Weller Manufacturing Co.

117—CHAMBER.—A chamber is a small kiln or room of a continuous kiln. Usually only one chamber is being burned at a time and the warm air is being drawn from those that have been burned. The hot gases from the burning chamber are sent thru the chambers that are to be burned, preheating and water-smoking them. Some continuous kilns do not have chambers but are built like a very long rectangular kiln, and temporary removable partitions are placed in the setting. These partitions really form chambers until removed. (See also several items headed Kiln, continuous.)

118—CHARTS, GRAPHIC, ETC.—These are used to visualize the variation in cost, quantity of production, loss and in fact any phase of factory operation. The usual type consists of any number of cross section lines, that is, lines drawn vertically and horizontally at uniform distances. They are used by considering one set of lines, say the vertical lines as representing spaces of time. Thus every vertical line can represent a day or a month or any period of time. The horizontal lines represent units, divided equally but with any range desired. The chart is used by making a dot where each date or vertical line crosses the line representing the number of units made that day, or the cost or whatever it is desired to show on this particular chart. The dots are either connected by short lines making what is called a crooked line that goes up and down as the production or cost goes up or down, or the vertical lines are drawn very heavy from the dot to zero or lowest unit or horizontal line. The result is that no matter how little education anyone has, he can see vividly how the cost and production vary. If the former goes up and the latter down, it is evident that an investigation must be made to determine the cause and find a remedy. Charts show the necessity for an improvement and change much quicker, very much quicker than plain figures.

MANUFACTURER (see catalog section):
Brown Instrument Co.

119—CHASER-MILL. — Chaser-mills are often used in stoneware factories in the preparation of raw material, and may be considered as a form of wet pan. They consist primarily of a circular iron pan which contains a revolving frame to which are attached two narrow iron wheels, 30 to 36 ins. in diameter. As the frame revolves, the wheels, by means of gearing, travel around the pan in a spiral path. The clay and water are placed in the pan and the action of the wheels grinds and cuts it up, the tempering requiring from one to two hours. The action of the machine is quite thoro, but considerable power is required to operate.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Stevenson Co.

120—CHEMICAL PORCELAIN.—This covers such ware as crucibles, etc., used in the chemical industry. The composition is close to 25% flint, 25% feldspar, and 50% clay. Frequently some talc is added. This grade of porcelain is usually made very thin, and burned to Cone 15 or 16, the glaze being matured at the same temperature. The biscuit firing is usually done at Cone 09 to 4 or 5.

CHIMNEY, see Stack.

CHINA CLAY, see kaolin, ball clay, sagger clay and other descriptions under Clay; and the several entries under Chinaware, Porcelain and Pottery.

121—CHINAWARE.—The varieties and qualities of china or porcelain and the uses to which they are put are highly diversified, including such goods as the finest table and ornamental wares; goods particularly adapted to hotel and restaurant uses; fine qualities of kitchen, sanitary, laundry, and toilet utensils; door furnishings; electrical insulators in great varieties; vitrified tiles, etc.

The distinctive feature of china or porcelain is its translucency and vitreous or glassy fracture. This quality is produced by using a larger percentage of fusible material than is used in the manufacture of earthenware. Different countries produce this result by the use of different material, feldspar being the principal material used in United States, but the finest grade of chinaware produced in Great Britain, possibly in the world, is made from the admixture of the phosphate of calcium or ground bones. This is known as "bone china" in contradistinction to "spar" or "feldspathic" china.

The general distinction made between the different types of porcelain is that of hard and soft porcelain. The first term includes all of the compositions which are matured at Cones 13-14; the latter comprises those fired at temperatures below Cone 10. American porcelains are located at the dividing line between these two classes, and overlap into the field of softer bodies. Hard porcelain may vary in composition between 45-60% clay substance, 20-40% quartz, 20-35% feldspar, and 0-6% whiting (calcium carbonate). A commonly used body of this type consists of 50% clay substance, 20% feldspar, and 30% quartz. The main characteristic of European hard porcelain is that biscuit firing is carried only to a low temperature, about Cone 010, and the glost fire to Cones 13-14. The body matures, therefore, at the same time the glaze is fused to a transparent, smooth glass. This means that the glaze must be of a much harder character than the boro-silicate of whiteware. The most fusible porcelain glaze employed is represented by this formula:

$$\left.\begin{array}{r}0.3\ K_2O\\ .7\ CaO\end{array}\right\}\quad 0.5\ Al_2O_3,\ 5\ SiO_2$$

composed of 166.8 parts feldspar, 70 parts whiting, 51.6 parts kaolin, and 168 parts flint.

The higher the temperature of the glost burn the more silica and alumina the glaze must contain. The more difficultly fusible glazes may reach the limiting composition:

$$\left.\begin{array}{r}0.2\ K_2O\\ .8\ CaO\end{array}\right\}\quad 1\ Al_2O_3,\ 10\ SiO_2$$

composed of 111.2 parts feldspar, 80 parts whiting, 206.4 parts kaolin, and 432 parts flint.

Extremely hard glazes of this type are used on the porcelains of Danish and Swedish manufacture. Frequently, porcelain glazes are made somewhat more fusible by replacing the lime in part by magnesia introduced as magnesite.

The "soft" porcelains are represented chiefly by three types: (1) bone china, (2) parian porcelain, and (3) the Japanese porcelain with its modern adaptations, the "new" porcelain of Sevres and Seger porcelain.

Bone china is the typical vitreous product of England, characterized by its beautiful texture and adaptability to rich decoration. It is composed of from 40 to 50% of bone ash (calcined bone), 20 to 30% Cornish stone, and 25 to 30% clay substance. It is a body requiring considerable skill in its manufacture. The biscuit burn is carried to Cones 6-10, while the glaze is fused on at the temperature of whiteware glazes and corresponds closely to the latter.

Parian porcelain is intended principally for the manufacture of unglazed statuary and figures, and in this country is used for manufacturing white floor tiles. It is composed of 50% feldspar, 40% clay substance, and 10% flint. Its burning temperature is carried to Cones 8-9. In appearance it has an agreeable matt texture without the glassy sheen of the usual porcelain body.

Japanese porcelain is very white and translucent and is characterized by a high feldspar and low clay content. It has been reproduced in France as the new Sevres body, composed of 40% clay substance, 24% quartz, and 36% feldspar. All of the feldspar and parts of the quartz are introduced as pegmatite. The body is biscuited at a low temperature and is matured simultaneously with the glaze at about Cones 9-10. The formula of the glaze, according to Rieke, in "Das Porzellan," is as follows:

$$\left.\begin{array}{l}0.06\ K_2O\\ .09\ Na_2O\\ .85\ CaO\end{array}\right\}\quad 0.5\ Al_2O_3,\ 4.21\ SiO_2$$

composed of 42.1 parts feldspar (from southern France), 27.2 parts sand, 13 parts kaolin, 17.7 parts chalk (it should be noted that the composition thus given does not check with the above formula, assuming the usual constitution of the materials).

The Seger porcelain, so-called after the German ceramist, consists of 25% clay substance, 45% quartz, and 30% feldspar. This body is also biscuited at Cone 010 and matured with the glaze at Cones 8-10. The composition of the glaze is:

$$\left.\begin{array}{l}0.3\ K_2O\\ .7\ CaO\end{array}\right\}\quad 0.5\ Al_2O_3,\ 4\ SiO_2$$

and consists of 168.8 parts feldspar, 70 parts whiting, 51.6 parts kaolin, and 108 parts flint. Seger porcelain is used mostly for making art pottery.

(For origin and development of this industry, see Ceramics, a history of.)

122—CHISELS.—Metal tools or instruments with a cutting edge at the end of a blade, used in cutting, dressing, shaping or otherwise working on timber or metal. A wood chisel generally has the bevel all on one edge, but a metal chisel usually has a bevel from two edges. The cutting edge of a chisel may be narrow or wide and the bevel may be sharp or not depending on the work it is intended to do. A chisel for cutting hot iron, for instance, has a much blunter point than the same sized chisel for cutting cold iron. Blacksmith's chisels usually have a handle which fits thru a hole near the top. All chisels are made from tool steel and the cutting edges must be tempered according to the work to be done. (See also Tool steel.)

123—CHROME.—Chromic oxide, Cr_2O_3, is not fusible at temperatures used in any industrial practice. Chrome brick are made from chrome iron ore ($FeCr_2O_4$), and after allowing for the binding material the brick are found to contain about 40% of chromic oxide. It is very valuable, therefore, as a high grade refractory, and it has the additional property of resisting the chemical action of slags, gases and dust. It is valuable principally in steel and metallurgical furnaces, where the heat and chemical actions unite to destroy the linings. The most valuable deposits of chromite are found in Greece, but during the European war deposits in the states along the Pacific coast were developed. Chrome brick are classed as neutral refractories.

CLAMP KILN, ENGLISH, see Kiln, intermittent, up-draft, temporary.

124—CLAM SHELL.—A bucket arrangement which hangs on the end of a cable suspended from a crane or boom. Various types are made, e. g., scraper, orange peel, single hook, automatic. All are controlled at a distant point by the tightening and loosening of cables. Their use is for picking up clay, dirt, coal, ashes, stone or other heavy material and transporting to another point. In loading open top cars or boats or barges, they are suited to handle the rougher classes of clay products.

MANUFACTURER (see catalog section):
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of Patented Deck Sweeper Clay Grinders & Steam Heated Screens for overcoming troubles arising from lime.

125—CLAY.—The word clay is applied to those earthy materials occurring in nature whose prominent property is that of plasticity when wet. Because of this plasticity, they may be molded into practically any desired shape, which is retained when dry. In addition, if heated to redness, or higher, the material becomes hard and rock-like. Physically, clay is made up of a number of small particles mostly of mineral character, ranging from grains of coarse sand to particles of microscopic size, or under one one-thousandth of a millimeter in diameter. Mineralogically, clay consists (1) of many different mineral fragments, some of them fresh, others in all stages of decay, and representing chemically many different compounds, such as oxides, carbonates, silicates, hydroxides, etc.; (2) of colloidal material which might be of either organic or mineral character.

Clay deposits, however, vary so greatly in physical condition and in chemical composition that it is difficult to group them in fixed classes. Also, the methods employed in working clays, combined with the almost innumerable uses to which different kinds of clay are put, make it necessary to treat clay according to its individual requirements and to the requirements of the particular branch of trade for which it is intended. The primary object of the clayworker is to use the clay at his disposal, and repeated analyses of clays used in making brick, blocks, tiles and pipes are seldom necessary. Frequent tests are, however, essential to successful practice in the working of refractory clay, and of clays used in the production of porcelain and other high class wares. In fact, the closest possible attention is imperative in the manufacture of the best wares, not only as regards the clays used, but also as regards the other materials employed, without which the clay is practically useless to the potter.

In the following paragraphs a brief description of the various clays found in this country is given beginning with the highest grades, with further reference to the uses to which each kind of clay is put.

Kaolin.

Kaolin, as it is commonly accepted, refers to those white burning clays of residual character, which are composed mostly of silica, alumina, and chemically combined water, and have a very low percentage of fluxing impurities, especially iron. In this country, kaolins have been formed chiefly by the weathering of pegmatite veins, and in rarer instances from feldspathic quartzites, limestone, and talcose schists. There are other occurrences, such as those of Edwards County, Tex., and the indianaite of Indiana, whose origin seems doubtful. Also, in the coastal plain of the Southern Atlantic States, white burning sedimentary clays are found which are sometimes called kaolins, but these are usually classed as plastic kaolins to distinguish them from the residual kaolins. The known workable deposits of kaolins found in United States are located east of the Mississippi river, except those found in Missouri, Utah and Texas. Deposits of this type may contain a high percentage of the mineral kaolinite (see this entry), this being assumed because after washing the sand out of such materials, the silica, alumina, and water in the remaining portion are in much the same ratios as in kaolinite, altho other aluminous silicates may at times be present. Properly, while the term kaolin is sometimes applied to any residual clay, it is generally agreed that it should be restricted to white burning clays. Tested physically, kaolins all show a low air shrinkage, low tensile strength, are white burning and usually highly refractory. The kaolin of North Carolina, considered the best in this country has a fusion point of about cone 33, which is 1,730 deg. C. (3,146 deg. F.).

Porcelain and china ware are made from kaolin.

Ball Clay.

Ball clay includes those white burning plastic clays of sedimentary character which are used as a necessary ingredient of whiteware mixtures in order to give the body sufficient plasticity and bonding power. They must contain little or no iron oxide, and possess good plasticity and tensile strength. They have a high drying and burning shrinkage and vitrify at a lower temperature than kaolin. This is due both to their fine grain and their content of fluxes. When iron is present to a small extent it tends to make the finished color cream or ivory, and upon vitrification turns to a gray. For this reason only a small percentage of ball clay is used in whiteware bodies, 10% being the usual amount and 15% the high limit in America. The ball clay most commonly used comes from England, Tennessee or Kentucky. Florida, New Jersey, and Missouri also have deposits. Refractoriness is a desirable quality, the imported ball clays vitrifying at or near cone 8, and the native clays requiring a higher heat for vitrification.

Fire Clay.

The term fire clay, properly speaking, refers to those clays capable of withstanding a high degree of heat; and, in the opinion of some authorities, no clay should be classed as a fire clay unless its fusion point is higher than that of cone 27. The common practice of grading, as in some localities, both fire clays and brick clays as No. 1 and No. 2, is admittedly erroneous, as is also the still more common practice of applying the term fire clay to all clays found underlying coal beds.

Fire clays contain practically all the substances usually determined by the ultimate analysis, but in every good fire clay the total percentage of certain fluxing impurities, such as ferric oxide, lime, magnesia, and alkalies, is small. This is essentially true, because, if fluxing impurities were present in large quantities, the clay would fuse at comparatively low temperatures and could not be classed as refractory. As in kaolins, the chief constituents of fire clays are silica, alumina, and water.

Aside from the essential factor of refractoriness, fire clay may vary widely in plasticity, shrinkage, texture, color, tensile strength, and other physical properties, all of which affect the behavior of the clay during the processes of manufacture, but none of which can be used as a sure guide in determining its probable refractoriness. Color may help under certain conditions, as pure white clays and light yellowish clays are often at least semi-refractory and sometimes highly refractory. Some fire clays are tinged a deep yellow or yellowish red, as tho they contained considerable iron oxide, and yet they have excellent heat resistance. If the clay is black or bluish black, there is no means of telling from mere inspection what its heat resisting qualities are, as under these conditions, a clay with very little iron oxide and one with very much might outwardly appear the same.

Fire clays may be of either residual or sedimentary origin, the latter being the more important commercially. This class is further subdivisible into plastic fire clays and flint clays. The former are plastic when wet, the latter are hard and flint-like, with a smooth, shell-like fracture and dense texture. They develop but little plasticity, even when ground fine, but are usually highly refractory.

In the United States, fire clays are widely distributed, both geologically and geographically. The most important occurrences are in the Carboniferous in Ohio, Pennsylvania, Indiana, Illinois, Maryland, West Virginia, and Missouri. Many other deposits are found in the Cretaceous of New Jersey, Maryland, Georgia, South Carolina, Alabama, Texas, Iowa, Colorado, South Dakota, etc., and in the Tertiary of New Jersey, Georgia, South Carolina, Alabama, Arkansas and California. In Pennsylvania, Maryland, Alabama, and North Carolina some pre-Devonian occurrences are found, but only to a limited extent.

Fire clays are used mainly for the manufacture of various shapes of fire brick, but in addition they are used wholly or in part in the manufacture of gas and zinc retorts, locomotive and furnace linings, crucibles, floor tiles, terra cotta, conduits, pressed and paving brick, etc.

A special grade of fire clay, obtained from Pennsylvania and Missouri, or imported from Germany, is known as glass-pot clay, and is used in the manufacture of glass pots and blocks for glass-tank furnaces.

Stoneware Clay.

Stoneware is usually made from a refractory or semi-refractory clay, altho in some small potteries a much lower grade of material is used. Frequently, the material is as refractory as that used for fire brick, but differs from the latter in burning to a very dense body at a comparatively low temperature. It should have sufficient plasticity and toughness to permit its being turned on a potter's wheel. The non-plastic grains may range from 0.002 to 0.01 of an inch in size. Coarse sand renders the clay so absorbent that it will not hold its shape in turning. The percentage of fluxes must be large enough to insure partial vitrification so that the body of the ware is made substantially impermeable to liquids, and at the same time the clay must be sufficiently refractory to keep its shape in a salt-glazing heat. A tensile strength of 125 lbs. per sq. in. or over is desirable, and the clay should also show low fire-shrinkage. Concretionary minerals, such as iron or lime, which are liable to cause blisters, should be avoided. Orton (Ohio Geol. Surv., VII, p. 95) gives the following average of ten separate analyses of stoneware clays in use in Ohio potteries: Clay base, 56.65; sandy matter, 37.45; fluxing matter, 4.44; moisture, 1.57; total, 100.14; total silica, 65.09.

Stoneware clays are found in certain portions of New York, New Jersey, Missouri, Texas, Ohio and Indiana, and are used not only for the manufacture of all grades of stoneware, but also for yellow ware, art ware, earthenware, and recently even for terra cotta.

Terra Cotta Clay.

Terra cotta is made from many different kinds of clays, altho most terra cotta manufacturers are now using semi-fire clays, or a mixture of these with a more impure clay or shale, since these give the best results at the temperatures (cone 6-8) usually attained in their kilns. Some are used because of their dense burning character and bonding power, others because of low shrinkage and freedom from warping, while absence of soluble salts is an important as well as desirable property in all. Buff burning clays are commonly chosen, partly because they burn to a hard body at the desired temperature, and there is little danger of overburning. Color of body has no great importance, since the final color is applied superficially. Soluble salts are undesirable, because in drying they may come out thru the color-slip; but they can be rendered insoluble if necessary by treating the clay with barium chloride or carbonate.

A tabulated statement of properties of clays used for terra cotta manufacture would involve an extensive list, but it is interesting to note the properties of a terra cotta mixture used in a large eastern factory, the tests being made on a soft green body as tempered at the works (see N. J. Geol. Surv., VI, p. 270, 1904). Its physical properties were as follows:

Air-shrinkage, 4½%; tensile strength, 97.5 lbs. per sq. in. Its behavior in burning was as follows:

Fire-shrinkage; 1.5% at Cone 01, 4.8% at Cone 5, 5% at Cone 10. Hardness; not steel-hard at Cone 01, nearly steel-hard at Cone 5. Absorption; very absorbent at Cone 01, slightly absorbent at Cone 5, nearly impervious at Cone 10. Color; pale buff at Cone 01, gray buff at Cone 5, gray buff at Cone 10.

In making terra cotta the clay is not carried to temperature of Cone 10, as there would be danger of its warping; but it is usually fired between Cones 6 and 8, the danger being largely, if not entirely, diminished at this point.

Clays suitable for terra cotta manufacture are widely distributed, but those mostly used in this country are the Cretaceous of New Jersey and the Carboniferous of Pennsylvania, Indiana, and Missouri.

Sewer Pipe Clay.

As sewer pipes must be vitrified in burning, they require a clay high in fluxes, and the clays used are very similar to those needed for paving brick manufacture. Ordinarily, some fire clay is mixed in with the vitrifiable material, to hold its shape better in burning. A high iron percentage is said to aid the formation of the salt glaze with which the pipes are covered, but a high percentage of soluble salts is objectionable.

Sewer pipe clays in eastern and central states are obtained chiefly from Carboniferous formations, and to a small extent from Devonian ones. The Cretaceous and Tertiary beds of the coastal plain states are not as a rule adapted to sewer pipe manufacture; but in the Rocky Mountain region and Black Hills area some of the Cretaceous clays have good vitrifying qualities. Pleistocene clays are used only to mix in with other materials. Two of the necessary qualities of sewer pipe clay are that it contains enough silica and stands sufficient heat to combine with the fumes of salt to produce the required glaze.

Common Brick Clays.

Clays or shales used for common brick are usually of a low grade, and in most cases red burning. The main requisites are that they shall mold easily and burn hard at as low a temperature as possible with a minimum loss from cracking or warping. Many common clays or shales when used alone show a higher air- and fire-shrinkage than is desirable, and it is customary to decrease this by mixing some sand with the clay or by mixing a loamy or sandy clay with a more plastic one.

Common brick clays vary widely in their composition, but most of them contain a rather high percentage of fluxing impurities. The chemical composition of common brick clays is of importance in affecting the color-burning qualities, but the physical characteristics are even more important, as they affect not only the color in burning but often exert an influence on the process of manufacture to be chosen.

Common brick clays are widely distributed, both geologically and geographically, among them being the adobe clay and loess clay of common occurrence west of the Mississippi River.

Adobe clay is a calcareous silty clay, common thruout the southwestern states and much used for making sun-dried or adobe brick.

Loess is the term applied to extensive Pleistocene deposits, which are not unlike adobe, but regarding whose origin there has been much dispute, some claiming them to be of subaqueous origin, while others consider them to be aeolian formations. The loess is a common deposit thruout the Mississippi Valley, and much used for brick making.

Face Brick Clays.

The clays now in use for face brick fall principally into one of three groups—(1) red burning clays; (2) white burning clays; and (3) buff burning clays, usually semi-refractory. The physical requirements of a face brick clay are (1) uniformity of color in burning, (2) freedom from warping or splitting, (3) absence of soluble salts, and (4) sufficient hardness and low absorption when burned at a moderate temperature. The air-shrinkage and fire-shrinkage, as well as tensile strength, vary within the same limits as common brick.

Red burning clays were formerly much used, but in recent years preference has been given to other colors. Buff burning, semi-refractory or refractory clays are now widely used, partly on account of their color and partly because coloring materials can be effectively added to them. These artificial coloring agents are used because of the limited range of colors that can be produced in burning. Manganese is the one most employed.

Face brick clays must necessarily burn hard at a moderate temperature. In the case of red burning clays the temperature reached may range from the fusing point of Cone 06 to Cone 2, while for buff burning clays it is commonly necessary to go to Cone 7 or 8 to get a steel-hard brick, unless calcareous materials are employed, and these are not burned above Cone 3, or even Cone 1.

Enameled Brick Clays.

These are similar to the clays employed in the manufacture of buff pressed brick. The enamel is, of course, an artificial mixture, but must conform to the clay body to avoid cracking or scaling off of the coat.

Paving Brick Clays.

A considerable variety of materials is used for paving brick manufacture, ranging from common surface clays to semi-refractory ones, but those most frequently employed are impure shales, these being often found to give the desired vitrified body at not too high a temperature. Shales of this character are widely distributed, geologically and geographically, but those most extensively worked are in the Carboniferous of Ohio, Pennsylvania, Indiana and Illinois. Devonian shales, in New York and Maryland, have yielded excellent results, and in the western states, Colorado, for example the Cretaceous shales are of importance in this connection.

Analyses of paving brick shales by the Missouri Geological Survey and the Iowa Geological Survey show a rather high percentage of total fluxes.

Clays for paving brick should possess fair plasticity, since they are commonly molded by the stiff-mud process; they should have good tensile strength, and a range of not less than 250 deg. F. between the points of incipient vitrification and viscosity.

Fireproofing and Hollow Brick Clays.

The clay used for making hollow brick and fireproofing vary with the locality. In a number of yards where red brick are manufactured the red burning surface clays of Pleistocene age are employed. In New Jersey, a mixture of red burning sandy clay and a small amount of low-grade fire clay is chosen. In the states of the eastern and central coal-measure areas, as in Pennsylvania, Ohio, Indiana and Illinois, Carboniferous shales are widely used.

For this reason it is difficult to give any fixed set of requirements for raw materials of this class. In general, however, they should have sufficient plasticity to flow smoothly thru the peculiar shape of die used in making them; they should possess fair tensile strength and burn to a good hard, but not vitrified, body at a comparatively low cone.

Slip Clays.

A slip clay is one that contains such a high percentage of fluxing impurities, and is of such texture, that it melts at a low cone to a greenish or brown glass, thus forming a natural glaze. It must be fine-grained, free from lumps or concretions, show a low air-shrinkage, and mature in burning as little above Cone 5 as possible. While easily fusible clays are not uncommon, all do not melt to a good glaze.

A good slip clay (see Ia. Geol. Surv., XIV, p. 224) makes a glaze which is free from defects common to artificial glazes. It will fit a wide range of clays, and since it is a natural clay it will undergo the same changes in burning as the body on which it is placed. Artificial mixtures of exactly similar composition to the natural clays have failed to give the excellent results as to gloss or color that are attained by the natural clay.

Several fair slip clays have been found in different parts of the country, but the most thoroly satisfactory material comes from Albany, N. Y., and is shipped to all parts of United States for potters' use.

Gumbo Clay.

This class includes certain fine-grained, highly plastic, tenacious clays of surface character, which are found at many points in the western central states. Their high shrinkage and dense character prohibits their use for brick making, but they are found excellently adapted to the manufacture of railroad ballast.

Retort Clay.

A dense-burning, semi-refractory clay used largely in the manufacture of gas retorts and zinc retorts. In New Jersey this name is often applied to stoneware clays.

Pot Clay.

Used for the manufacture of glass pots; a very dense-burning fire clay. It ranges from a highly refractory to a refractory clay. See the paragraph headed fire clay above.

Ware Clay.

A term sometimes applied to ball clays, especially in the Woolbridge, N. J., district.

Pipe Clay.

Applied to almost any fine-grained plastic clay; technically, it refers to a clay used for making sewer pipe.

Sagger Clay.

This term is applied to clays which are used in a mixture for making the saggers in which the whiteware and other high grades of pottery are burned. They are commonly rather siliceous in character, altho some may be used because of their bonding power and freedom from grit to hold the more porous grades together. Physically, sagger clays are not confined to any one type. Their refractoriness varies from that of a refractory to a semi-refractory clay.

Wad Clay.

A low grade of fire clay, used for grouting the joints between the saggers when they are set up in bungs in the kilns.

ANALYSES SHOWING VARIATION IN COMPOSITION OF CLAYS

	I.	II.	III.	IV	V	VI.	VII.	VIII.	IX.	X.
Silica (SiO_2).	46.3	45 70	57 62	59 92	68.62	82.45	54.64	38.07	90.00	47 92
Alumina (Al_2O_3). .	39.8	40 61	24.00	27 56	14.98	10.92	14 62	9 46	4.60	14 40
Ferric oxide (Fe_2O_3) . .	.	1.39	1.9	1 03	4.16	1 08	5.69	2.70	1.44	3 60
Ferrous oxide (FeO). .	...	...	1.2	. .	. . .	. .	.		. . .	
Lime (CaO).	....	.45	.7	tr.	1.48	.22	5.16	15.84	.10	12.30
Magnesia (MgO) . . .	....	.09	.3	tr.	1.09	.96	2.90	8.50	.10	1.08
Potash (K_2O).	....	2.82	5	.64	3.36	.	5.89	2.76	tr.	1.20
Soda (Na_2O)	..	..	2			.			tr.	1 50
Titanic oxide (TiO_2). .	...	....	..	. .	....	1.00	....	....	.70	1 22
Water (H_2O).	13.9	8.98	10.5	9.70	3.55	2.4	3.74	2.49	3.04	4 85
Moisture.	....	.35	2.7	1.12	2.78	....	.85		...	..
Carbon dioxide (CO_2). ..	...	.. .	....	....	....	....	4.80	20.46	....	9.50
Sulphur trioxide (SO_3).	....	...	.35	....	....	....	....	....	....	1.44
Organic matter.	.	..	..	....	.. .	....	....	....	....	1.34
Manganous oxide (MnO)		. ..	.	.	64	...	.76	....	...	.
Total.	100 00	100.39	99.97	99.97	100.66	99.03	99.05	100.28	99.98	100 35

I. Kaolinite.
II. Kaolin, Webster. N. Ca.
III. Plastic fire-clay, St. Louis, Mo.
IV Flint fire-clay, Salinesville, O.
V Loess-clay. Guthrie Centre, Ia.
VI. Rusk, Cherokee County, Tex.
VII. Brick shale, Mason City, Ia.
VIII. Calcareous clay, Milwaukee, Wis.
IX. Sandy brick-clay, Colmesneil, Tex.
X. Blue shale-clay, Ferris, Tex.

Portland Cement Clay.

Clays or shales to be used for Portland cement manufacture should be as free as possible from coarse particles or lumps of sand, gravel, or concretions. These conditions are best met by transported clays, as residual clays are often sandy or stony, and many glacial clays notably so. Analyses of clays used at different cement plants show that the silica percentage ranges from 50 to 70%; when calcareous clays are used it may fall below 50%.

Paper Clays.

The best grades of paper clay are some imported washed kaolins, but large quantities of good paper clay are also obtained from the Potomac formations of Georgia, and the Cretaceous and Tertiary formations of South Carolina. The Algonkian kaolins of Maryland, Delaware and Connecticut, as well as the white residual Cambro-Silurian clays of southeastern Pennsylvania, have also been used for this purpose.

Paper clays are mixed with the wood pulp fibre, so that the latter can enmesh a certain amount of clay particles. Plasticity seems to play an important role, since a given paper will retain a larger percentage of plastic clays than of others. Sand is an undesirable constituent, altho it can often be eliminated by washing the clay. Whiteness of color is a third essential, and must be a primary character of a paper clay.

Mineral Paint Clays.

Certain clays and shales, when ground and mixed with oil, make a good grade of mineral paint. Their color in most cases is due to some form of iron oxide, or more rarely manganese. Ocher is often merely a fine-grained ferruginous clay colored by limonite, and the same may be true of sienna. The value of the material depends largely upon the shade of color, its texture, and the amount of oil that has to be mixed with it in order to get the proper degree of fluidity.

Ultramarine Manufacture.

Washed kaolin or even very fine-grained white sedimentary clays are used in the manufacture of ultramarine to serve as a nucleus for gathering the coloring material. For this work the clay should be as low in iron or lime as possible, and an excess of silica is undesirable.

Polishing and Abrasive Materials.

Many clays exert a combined polishing and abrasive action, because of the very finely divided grains of sand they contain. The well-known bath brick, used extensively in homes for scouring steel utensils, is simply a fine-grained siliceous clay, which is deposited during high tide on the banks of the Parrot river in England.

Some clay is used for bonding purposes in the manufacture of corundum wheels. They are burned before use, so that the clay vitrifies and holds the corundum grains together.

125A—CLAY, CHEMICAL ANALYSIS OF.—The attached table taken from Ries' Clays, Occurrences, Properties and Uses, shows the variation in chemical composition of various types of clays, taken from various localities.

CLAY CRUSHER AND PULVERIZER, see several items under Crusher, Pulverizer and Disintegrator.

126—CLAY DEPOSITS, CLASSIFICATION OF.—Clays may be classified according to their origin, chemical and physical properties, or uses. The geologist is probably chiefly interested in the first of these, while the technologist is concerned with the second and third. There are a number of classifications in current use, the majority of them being principally based on genetic features, and sometimes secondarily on the properties of the clay. Orton's classification (Ohio Geol. Surv., VII, p. 52); Wheeler's Classification (Mo. Geol. Surv., XI, p. 25, 1897); Ladd's classification (Ga. Geol. Surv., Bull. 6-A, p. 12, 1898); Buckley's classification (Wis. Geol. Surv., Bull. VII, Pt. 1, p. 14); E. Orton Jr.'s classification (see Ia. Geol. Surv., XIV, p. 40, 1904); Grimsley and Grout's classification (W. Va. Geol. Surv., Vol. III, p. 70, 1906), and Ries' classification (Clays: Occurrence, Properties and Uses, published by Wiley & Sons, New York; see p. 27) are probably the best known and most used in United States. Ries' classification follows:

Class A:

Residual clays; formed by decomposition of rocks in situ. Consists of two main classes: (1) kaolins, or china clays (white burning), which may be found in (a) veins, derived from pegmatite; (b) blanket deposits, derived from extensive areas of igneous or metamorphic rock; (c) pockets in limestone, as indianaite. (2) Red burning residuals, derived from different kinds of rocks.

Class B:

Colluvial clays, representing deposits formed by wash from the foregoing and of either refractory or non-refractory character.

Class C:

Transported clays. Consists of four classes, with subdivisions as noted: (1) Deposited in water. (a) Marine clays or shales. Deposits often of great extent.—White burning clays.—Ball clays.—Fire clays or shales. Buff burning.—Impure clays or shales; may be calcareous or non-calcareous.—(b) Lacustrine clays (deposited in lakes or swamps); may include fire clays or shales; impure clays or shales, red burning; and calcareous clays, usually of surface character.—(c) Flood-plain clays; usually impure and sandy.—(d) Estuarine clays (deposited in Estuaries); mostly impure and finely laminated.—(2) Glacial clays, found in the drift, and often stony; may be either red or cream burning.—(3) Wind-formed deposits (some loess).—(4) Chemical deposits (some flint clays).

127 — CLAY, DESIRABLE PROPERTIES OF.—The physical and chemical properties of clay to be considered, and the beneficial effects of which it is desired to know, are:

1. Working qualities
   a. plasticity
   b. tensile strength
   c. drying shrinkage
      (1) tendency to warp
      (2) tendency to crack
2. Burning qualities
   a. color
   b. fire shrinkage
      (1) tendency to warp
      (2) tendency to crack
   c. degree of vitrification
      (1) porosity
      (2) specific gravity
   d. texture
   e. ability to take superficial coatings
      (1) engobes
      (2) glazes

(See entries on Plasticity; Tensile strength; Shrinkage; Porosity; Specific Gravity; Drying; Burning.)

CLAY FEEDER AND MIXER, see Feeder and mixer, clay.

CLAY GATHERER AND HARVESTER, see Gatherer and harvester, clay.

CLAY MINING, see Clay winning.

128—CLAY PLANT LOCATION AND DESIGN.—In selecting a clay plant site, primary consideration must be given to such important items as drainage, water supply, railroads, markets, and freight rates. Also, as every successful plant will grow, it is necessary to provide in the original plans some suitable method or means of taking care of future expansion. Ordinarily, land in the vicinity of a clay plant increases in value, so that a considerable excess in the original purchase may later be disposed of at a profit.

Ware to Be Produced.

There are two ways of approaching this subject: (1) to determine, first, the ware to be made and then to seek a suitable deposit of raw material, and (2) to determine by thoro tests what types of ware can be produced from the deposit after it is located.

This subject is often approached the wrong way: either the product is determined on without giving proper consideration to the raw material available, or the raw material is chosen without first wisely considering the product it is intended to manufacture. Many cases of plant failures, as far as the original owners are concerned, may be traced to having started operations before it was discovered that the raw material was not suited for the product to be manufactured.

Capacity or Output.

In considering the question of the capacity of a new plant, it is generally better to figure under than over, since if more ware can be produced than can be disposed of, a portion of the investment must stand idle, whereas, if the reverse is true, it is comparatively easy to add new equipment.

Most plants, as originally designed, are poorly balanced, one or the other of several departments being unable to produce what the others can take care of. Especial care should be exercised in working out and carefully balancing the dryer and kiln departments.

It is seldom economical to operate machine equipment whose capacity considerably exceeds the required output; e. g., using a brick machine having 100,000 capacity per day when only 50,000 are made. A more sensible procedure would be to install a 60,000 capacity machine and install an additional unit when the increased demand calls for it. Besides the fact that a 100,000 capacity machine will produce 50,000 brick in a half day and thereby create a problem on how the crew may be disposed of the remainder of the day, there is also the factor of power to be considered. Thus, a power plant capable of operating the large unit would be required, and every machine from pan to pug-mill would have to have the maximum rating or a great loss of efficiency would occur.

Dryers, on the other hand, are likely to be under the desired capacity, and it is always advisable to allow considerable leeway in this department, especially as the depreciation is very low. It is not good practice to provide more kilns than can be efficiently used, but this is seldom done. The reverse is often true. Kilns depreciate heavily when not in use, particularly in winter weather.

Choice of Equipment.

Clay machinery manufacturers have greatly improved their equipment in recent years, and the question now is largely a matter of proper selection. The beginner should never contract for equipment on a "price" basis (the experienced clayworker is generally too wise for that), but should, when he is not thoro familiar with the requirements, either consult an engineer or another clayworker who is acquainted with the products to be made. Many new plants have in the past been badly handicapped by unsuitable equipment.

Storage of Raw Material.

Proper storage facilities are imperative if the plant is to operate on a year-round basis. In cold climates, frozen shale or clay is encountered in winter, and in warm climates the winter season is generally wet. Rainy days will drive the pit crew from their work, with consequent costly shutdowns and losses. Where clay is mined underground, storage is not so essential.

Ordinarily it is not necessary to have an expensive storage shed or building; an open building, roofed over, usually serves the purpose.

With good management, a clay or shale pit can, as a rule, be operated much of the time during the winter months, and where only a storage building for minimum requirements can be afforded, it is merely necessary to make it of sufficient capacity to carry the plant over protracted cold or wet spells. The men who handle the pit can be used in the shed when bad weather makes it necessary to draw on the storage, unless conditions warrant the installation of mechanical handling equipment.

Drying Equipment.

A description of the structural and operative detail of the various types of dryers may be found under Dryers; but the selection of a drying system should only be made after thoro consideration has been given to the nature of the raw material, the character of product, the waste heat available and its source, and the price of fuel. Consultation with engineers or clayworkers who have had broad experience with the line to be manufactured will also pay well in the long run.

Burning System.

The selection of a burning system is so bound up with the kind of product, location of plant, size of plant and fuel available that, in this case also, no decision should be reached before a thoro investigation has been made to determine the exact requirements. The systems available are the intermittent types of up-draft and down-draft round and rectangular kilns, the continuous kiln, and the railroad tunnel kiln. Each of these types is comprehensively described under Kilns. Usually, the type in most successful and general use in the vicinity of the proposed plant, and in use on the same class of ware, is the safe type to select. This again, however, is a question that should be referred to a recognized authority before a decision is made, since each plant presents an especial problem in itself.

Laying Out the Plant.

Standard plans in an industry of such diverse requirements are impractical, but in a general way the following outline will enable the man with some mechanical ingenuity to handle the planning successfully.

After the equipment, dryers, type and number of kilns, etc., have been fully decided upon, a small drawing, absolutely to scale, should be made of the plan (floor area to be occupied) of each machine. The dimensions should be taken from the blueprints furnished by the machinery companies. Similar drawings, always to the same scale, should be made of the engines, motors, and boilers; in fact, this should be done for each piece of equipment that goes into the factory. The dryers and kilns should be handled in the same way, a separate drawing being made for each tunnel and kiln.

When these are completed, each drawing should be cut out along the exterior lines. Then, with the aid of an architect's scale, they can be arranged on a large sheet of paper in any manner that seems most advisable, and when finally a layout that seems to be the most compact and efficient has been arrived at, the outline of the buildings, tracks, switches, etc., can be sketched in around them. The merit in this method consists of the convenience with which any number of different arrangements may be tried by merely moving the small cut-out drawings around, and then critically studying the arrangement for defects. The method also makes it easy to allow for the proper clearance around each piece of equipment, the proper pulley centers, and to avoid crowding, as well as to tell at a glance whether the material is kept constantly flowing in one direction without any back-tracking.

By making an extra set of these small outline plans and using a surveyed plan of the property, it is a simple matter to provide for future factory growth and expansion.

Admit Plenty of Light.

As the plant will manufacture the best of structural products, the buildings should really be an advertisement. Light buildings are almost essential if a good product is to be made. It is just as cheap to put in glass and sash as to fill the same space with good brick, and plenty of light and air should be provided. The elimination of fire risk is also an important item, and as most plants are of single-story type, practically no lumber is required except in the roof-trusses.

Power Considerations.

In deciding the question as to the power that will be used a balance must be made between the individual plant and purchased power. On the individual plant the installation of boilers, engine, shafting, pulleys, feed-water pumps, etc., are part of the original investment, with fixed charges for the services of engineers, fuel, fuel handling and boiler compounds as additional considerations. Against this there is the cost of purchased power and motors. Installation expense and repairs are not considered, but will be in favor of purchased power.

Aside from the above, the flexibility of motor drives is a vital factor, since a far more flexible and compact plant can be built, usually at a saving in building cost. In addition, troublesome belts can be replaced with chain drives and line-shafts and countershafts eliminated.

Here again, all details should be thoroly canvassed before a decision is made.

Construction of Plant.

Building construction is a business in itself, and there can be no question as to the general advisability of letting plant construction out on contract. The many clumsy, dark, unhandy plants seen on every side are proof of the inability of the average clay plant operator to erect suitable buildings. Frequently, the contractor's wide experience will enable him to point out the defects in the original plans and to offer time- and money-saving suggestions; and if the contract is on a time and material basis, he can generally secure the materials cheaper than can an outsider.

The clayworker himself, however, should personally have charge of the setting of his equipment (provided he is capable of doing so), and the construction of the kilns. Kilns built on contract are seldom satisfactory. As they represent a considerable investment and much of the success of the plant will depend upon efficiency, great care should be exercised in their erection.

DESIGNERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.
Rodgers, L. E., Engineering Co.

129—CLAY, PREPARING AND WEATHERING.—The preparation of clays embraces a threefold object: (1) the homogenizing of the materials, (2) the purification of the clays, and (3) the development of plasticity. If the processes of mixing involve simply the use of one material of practically constant physical and chemical constitution, the problem becomes simple. But where it involves the mixing of dissimilar substances, such as two different clays, or shales and clays, clay and grog, etc., it is important that the materials be uniformly mixed in order to obtain a uniform product. There are a number of different processes involved in clay preparation, such as (1) choice of materials at the bank, (2) weathering process, (3) proper proportioning of the materials, (4) grinding or disintegrating, (5) sizing the grains, or screening, and (6) development of plasticity.

The weathering of clays in some instances is of great importance. In general, the outcrops and overburden are already weathered to 5, 10 or even 15 ft. down, due to the action of such agencies as rain, air, frost, etc., upon them. The chief changes resulting from weathering are the breaking up of the hard rock by such action as that of changes of temperature, etc., and the chemical changes due to soluble salts being leached out by water. The soluble salts are principally the sulphates of lime, alumina, and the alkalies. Other chemical changes are a change of ferrous iron to ferric, and of sulphur to sulphuric acid, which in turn may form sulphates.

The weathering of shales not affected by natural weathering may be accomplished in several ways: (1) Dig the shale and place it on a pile of not very great height, allowing the action of the weather to take place for six months or more. (2) Grind the clay or shale and then dump it in thin layers over a long pile in a storage bin by means of an automatic tripper. This method facilitates the weathering or aging of the clay or shale, and may improve the plasticity of a clay in comparatively short time. Hard shales in the ordinary process of preparation for cruder clay wares develop very little plasticity; but, if weathered, are frequently brought to a high degree of plasticity.

Weathering, however, is not a panacea for all clay ills, and when it is found that weathering does not improve the working qualities of some clays in the bank, they should be avoided.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.

130—CLAY PRODUCTS, CLASSIFICATION OF, IN CERAMIC INDUSTRY.—The various general classes of clay products, graded by the nature of the material from which they are made, shapes, uses, etc., may be outlined as follows:

Class A: Earthy or Stony.

- I. Structural material:
  - (a) Red or cream burning.
    - 1. Common or face brick.
    - 2. Hollow brick and block.
    - 3. Porous brick.
    - 4. Drain tile.
    - 5. Conduits.
    - 6. Roofing tile.
    - 7. Fireproofing material.
    - 8. Some terra cotta.
    - 9. Miscellaneous.
  - (b) White or light burning.
    - 1. Fire refractories of all kinds.
- II. Pottery.
  - (a) Not white burning.
    - 1. Artificial pottery.
    - 2. Common earthenware.
    - 3. Coolers.
    - 4. Flower pots.
    - 5. Yellow ware.
    - 6. Ordinary faience.
    - 7. Stone tile.
  - (b) White burning.
    - 1. White earthenware.
    - 2. Porous whiteware.
    - 3. Miscellaneous.

Class B: Vitreous Bodies.

- X. Vitreous only on edges.
- I. Structural material.

(a) Not white burning.
  1. Paving brick.
  2. Sewer pipe.
  3. Floor tile.
  4. Sewer tile.
  5. Conduits.
  6. Silo block.
(b) White burning.
  1. Acid-proof ware (or chemistry stoneware).

II. Pottery.
(a) Not white burning.
  1. Chemistry stoneware of all kinds, the shape deciding whether product is to be classed under pottery or not.
(b) White burning.
  1. Stoneware.

Y. Body translucent.

I. Structural material.
(a) Not white burning.
  None.
(b) White burning.
  1. Wall tile.
  2. Floor tile.

II. Pottery.
(a) Not white burning.
  None.
(b) White burning.
  X. Hard porcelains (those composed of spar, etc., and maturing at high temperatures).
  Y. Soft Porcelain.
    1. Low maturing material bodies.
    2. Bone china.
    3. Fritt, Seger, Parian porcelain.
    4. Dental porcelain.

131—CLAY PRODUCTS MANUFACTURE, NON-PLASTIC MATERIALS OF.—These may be divided into five general classes, with subdivisions as noted:

1. Silica: (a) sand; natural sand, crushed sand rock, and sandy clays; (b) flint; (c) infusorial earth.

2. Chamotte: (a) calcined clay proper; (b) waste and broken ware;

3. Lime: (a) shells; (b) chalk—crude and washed chalk; (c) limestone; (c) clinkers, etc., marble dust, common limestone, and dolomite.

4. Carbon: (a) graphite, and (b) coke.

5. Organic matter: (a) sawdust (b) straw, (c) turf, and (d) bituminous coal.

132—CLAY, PROSPECTING FOR.—Clay deposits can be more scientifically explored by geological methods, but there are a number of points by which beds of clay may be located by the observing clayworker.

Outcrops.

This is the usual method of detecting clay deposits, the exposures being commonly found on inclined surfaces, such as hilltops, or where natural or artificial cuts have been made. The washing out of gullies by heavy rains, the cutting of a stream valley, railroad or wagon cuts, all form good places in which to look for clay beds. The fresher the cut the better the exposure, since the sides of such excavations wash down rapidly, and a muddy red surface clay will often run down over a bed of lighter colored clay beneath, thus hiding it from view. If the cut is deep and freshly made, the depth of weathering can often be determined.

Springs.

One or more springs issuing from the same level along some hill slope may reveal the presence of clay. The springs may be caused by waters seeping down from the surface until they reach the top of some impervious clay stratum, which they then follow to the face of the bank from which they issue. On the other hand, springs cannot be used as a positive indication of clay, for a bed of cemented sand, or even dense silt, may produce the same effect.

Ponds.

In regions covered by glacial drift, pools of water are frequently retained in depressions, because of the presence of a water-tight bed of clay below them. This does not necessarily indicate a thick deposit, as a very thin layer may hold up a considerable body of water. The ponds may also be present even in the absence of clay, due to the seeping down of the groundwater from higher levels.

Vegetation.

In some regions, clay deposits produce a different type of plant growth from other soils, but, in this event, the character of vegetation can only be used as a subordinate aid in the search for clay.

After a clay deposit is located, it is necessary to determine its thickness, extent, character, and uses to which it can be put. The first two points and some facts bearing on the third may be learned in the field, but the behavior of the clay when mixed and burned must be learned by laboratory tests or in a clay plant, in order to obtain an accurate knowledge of the commercial value of the material.

Borings made with an auger furnish a quick and satisfactory means of learning the thickness of the deposit. By comparing the data obtained from boreholes and outcrops, any vertical or horizontal variations in the deposit can usually be traced. Limonite concretions or crusts, if existing in any abundance, will likely be discovered, and even the dryness of the beds can be approximately ascertained. Variations in the thickness of the bed and the amount of stripping are likewise determinable. Samples for laboratory tests can be secured from the outcrops and boreholes; where larger samples are required from intermediate points, test pits are sunk where the borings were made.

In some regions clay miners use an auger to guide them in their digging operations, since rapid variations may occur in any clay deposit.

PROSPECTOR (see catalog section):
Hadfield-Penfield Steel Co.

CLAY SCREEN, see several items under Screen.

133—CLAY TESTING.—In testing clay the more important properties are its physical behavior and pyrochemical reactions. A chemical analysis is but of little value. Two clays of identical chemical analysis may give altogether different results in manufacturing.

A chemical analysis will, however, serve as a guide and some properties can be determined from it. For instance, a high lime clay will give trouble in burning and in scumming; a high iron clay will usually burn to a deeper red color; a high silica clay may give trouble due to cracking or brittleness.

The important points to determine in making a test of clays and clay ware are its plasticity, drying shrinkage, tendency to crack during drying, fineness of grain, crushing strength, elasticity, cross bearing strength, hardness, toughness, rattler test, porosity, heat conductivity, electrical conductivity, coefficient of expansion, burning shrinkage, color, tendency to crack in burning, burning range, fusion temperature, spalling, and resistance to fluxing action.

There are but very few commercial laboratories equipped to make proper tests on clay, and the best way to test a clay is to make miniature samples and put them thru the process of manufacture.

Some of the clay machinery manufacturers are equipped to do this work, as are the ceramic schools and Bureau of Standards and Bureau of Mines. (See Shrinkage, Porosity, Plasticity, Conductivity, Fusion, etc.)

TESTERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

TESTER'S ANNOUNCEMENTS:
Bonnot Co., Canton, Ohio. Clay testing department maintained where clays are worked in standard machinery, giving accurate and dependable results.

134—CLAY WINNING.—Clays are commonly reclaimed from nature by surface digging, quarrying and mining.

The first of these is practiced where clays of the more earthy, loose-textured varieties occur at the surface of the ground and may be dug in shallow pits. The shovel and wheelbarrow constitute the primitive means of surface digging. This is the slowest and most expensive mode of operation. It cannot be used on any large plan, nor where clay must be transported any considerable distance. Another method is by the plow and scraper. These provide for more extensive operations than is possible with shovel and wheelbarrow, and the clay may be hauled economically some distance to the preparing machinery or to the terminus of the transportation line from pit to works. Under very favorable conditions, a haul of 500 or 600 ft. may be made.

Surface operation may ordinarily be termed a fair-weather proposition, since it is extremely difficult to employ a method that will permit continuous digging under all changes of weather, even in the working season. Heavy rains usually permeate the strata being worked, and may flood the pit with water.

For extensive surface digging operations, steam or electric shovels are employed, if the material is of a fairly friable nature. In clay pits where there is a vertical variation in the character of the strata, the steam or electric shovel may be used with advantage in averaging and maintaining a comparatively constant supply of raw material.

A shale planer is the best machine for mixing the several layers of a clay or shale deposit.

Quarrying.

Quarry methods are resorted to in digging clays where the nature of the latter or the thickness of the strata is such that more forcible means must be employed to loosen them than is provided by the pick, shovel and plow. Shales, for instance, where unweathered, are more or less indurated, and this induration may have proceeded to such an extent that the deposit has acquired a stony or slaty hardness which can only be broken up by drilling and blasting. Quarrying methods are principally applied to this class of clays.

In quarry practice, where faces over 20 ft. high are to be worked, best results are obtained by establishing an intermediate "bench." For instance, instead of taking down vertically a 30-ft. bank, it has been learned that in most cases it can be more advantageously removed by working two low faces of 15 ft. each. The chief difficulty in operating a quarry in a series of benches or steps is encountered in getting the material from the upper benches down to the means of transportation from the quarry.

In thoroly indurated rock like limestone and sandstone the question is less serious than in handling a shale quarry. By blasting, shales are shattered into fragments of various sizes many of which must be further broken up to permit their being handled with the shovel before leaving the pit. The difficulty involved in handling this partially broken-up material in a quarry consisting of several benches is evident where car lines can not be run at the different levels.

The bench or stair principle of quarry practice is not generally followed in the development of high clay banks, which, as a rule, are either taken down as a whole or worked at only comparatively low exposures at one time, each working face being of such a height that it can be loosened from top to bottom with the common sized charge of explosive. Ordinarily, the face of the bank is undermined as far as possible by picking, following which a series of charges is placed in drill holes arranged parallel to and a few feet back from the quarry face; these charges, set off simultaneously, break down and shatter large bodies of the clay.

Immense bodies of clay can be broken down by this means, and the material is left in such a loosened condition that weathering progresses more effectively and the clay is in better shape when delivered to the preparing machinery.

Clay Mining.

Mining is employed only where the clay to be won is of such a nature as to make it especially desirable for a certain line of manufacture, and where clay which will serve the same purpose is not available at the surface.

Mining a vein of clay is carried on according to the same principles followed in mining coal; that is, either by the so-called room and entry or pillar plan, or by the long wall system. The first method is employed where the veins are thick and much timbering is required; the second, where the veins are comparatively thin and where the overlying material is such that it furnishes a fairly stable roof.

MANUFACTURERS (see catalog section):
Eagle Iron Works.
Hadfield-Penfield Steel Co.

135—CLEANER, BOILER TUBE & FLUE, MECHANICAL.—Boiler tube and flue cleaners of the mechanical or power-driven types are generally (1) pneumatic, which derive their power from air or steam pressure, or (2) turbine, which operate on water pressure.

Pneumatic cleaners are usually supplied to operate on 40 to 100 lbs. pressure. The motor consists of an outer casing that contains, in the most approved types, a removable hardened steel cylinder, within which revolves an eccentrically mounted shaft, to which the reciprocating mechanism is attached. This mechanism consists of blades, placed side by side, but carefully balanced to reduce the friction between the blades and the cylinder. Air or steam is admitted to the cylinder thru ports in the walls thereof, and placed at definite intervals apart to produce uniform pressure on the blades. This pressure, applied to the blades within the cylinder (on the principle that water is applied to turbine blades) causes the shaft to revolve and thereby furnish driving power to the scale-cutting head.

Lubrication is supplied by a sight-feed lubricator attached to the air-line at the junction of the air-line and the manipulating hose. The oil is thus forced by air into the cylinder, along the cylinder walls, and to both the front and rear bearings. The ends of the cylinder are closed by wear plates. For lubrication, a good grade of lard oil or machine oil is used with air pressure, and a heavy cylinder oil for steam.

Various Types of Head.

The pneumatic cleaner is generally made with all mechanical parts easily removable and interchangeable, to facilitate repairs. It is also made in a variety of sizes, for bent or straight-tube work, to meet all requirements. The cutting head may vary in style from a plain, strong drill, for boring thru very heavy scale, to a ratcheting device, equipped with a number of gear-edged cutting wheels, for conveniently and quickly disposing of light scale.

Some types of pneumatic cleaners differ radically from the described type, but the working principle remains practically the same. After the machine has been completely connected up, and placed in the tube far enough to allow the cutters to engage the scale, the power may be applied and the machine fed into the tube gradually until it has traveled a distance of about six ins. from the front end. A small garden hose should then be inserted behind the cleaner and a stream of water allowed to flow into the tube being cleaned, as this moistens the scale and prevents dust in the boiler room. Care should be exercised to avoid too high pressure, as excessive pressure has a tendency to choke the machine and thus reduce its capacity for work.

The turbine boiler cleaner is built in sizes for all sizes and types of boiler tubes, and consists of a water turbine driving a rotating, freely swinging cutting head, which chips, cuts and drills its way thru the adhering scale as it is gradually fed into the boiler tube.

Details of Turbine Construction.

The body of the cleaner is generally made from high grade machinery steel, and is provided with a removable bearing. Ports in the rear of the cylinder introduce the water pressure to the turbine wheel, which is mounted on the rear of a hardened steel shaft. (In some types, the shaft is mounted on two bearings, instead of one.) All parts of the interior mechanism are usually designed to permit easy replacement, in case repairs are needed.

The turbine cleaner is generally lubricated by water, but may, when desired, be equipped with an oil-lubricating device.

The amount of work a turbine cleaner will perform depends upon the amount of water pressure available and the skill of the operator. A pressure of 100 to 125 lbs. at the cleaner inlet is essential for successful rapid work. To assure proper pressure, a gage should be placed on the water supply pipe to which the hose is attached and the pressure read when the machine is running at full speed. The use of too small hose is a frequent source of trouble, and can be avoided by always using a hose that will fit the coupling furnished with the machine. Dirt in the water also fills up the ports and reduces the capacity of the cleaner. Water containing chips, cinders and other foreign matter is responsible for the largest number of turbine cleaner failures.

When the turbine cleaner is not in operation it should be stored in oil to keep the parts from rusting.

When the machine is in operation, the bearings should be watched closely to prevent their wearing in excess of one-sixteenth in. before renewal.

In removing scale, the machine should be fed into the tube gradually, as jamming it against the scale cuts down the speed of the cutting head and thereby retards the work, and may result in considerable damage to the machine.

CLIP, RAIL, see Rail clip.

136—CLOCK.—Clocks are used in many offices and factories, and in some, the clocks which are regulated hourly by telegraph replace all others. In all factories, however, a time clock is a necessity. This consists of a clock by which each employee registers the time of his arrival and departure from his duties. In making up a pay roll a time clock is a check against any report of a foreman or of the piece work gang. The savings in mistakes of this kind in pay rolls will pay for a time clock in a very short time. In addition there are other time keeping clocks which consist of a clock arranged to stamp the time on a card very much like the date is stamped on a railroad ticket at the station. In some plants a master clock is located in the office and it controls, regulates and adjusts any number of other clocks scattered thruout the plant, thus making the time uniform at all points. The control is by means of electricity. (See also Recorder, time and operation.)

137—CLOCK, WATCHMAN'S.—These clocks are made to be used by a night watchman. They consist either of a portable clock which the watchman carries with him, or a central clock which registers the time that he was at a certain point. In the first type each station around a plant has a key permanently fastened to it. The watchman in making his rounds is expected to visit each station every hour or half hour. At each station he places the key for that station in a certain part of the clock. This operation registers the number of the station and the time on a dial of paper on the inside of the clock. This dial is replaced daily so that any neglect to visit each station at the proper time can be noticed. The central clock system works the same way except that the watchman places the key in a small receptacle at the station, which operation closes an electric current and registers the time and station number on a dial at the location of the central clock. This dial can be removed from the central clock every day also. (See also Recorder, time and operation.)

CLOTH, WIRE, see Wire cloth.

138—CLUTCH.—A clutch is an attachment on a machine or line shaft thru which power is transmitted to the machine or line shaft. The most common type is where the drive belt for a machine drives a pulley which is mounted loose on the main shaft of the machine. A casting is fastened solid to the shaft, and has shoes, arms, or plates which are movable and adjustable. The pulley has corresponding parts which interlock or match, and a lever is provided which fastens, locks or holds the movable parts on the casting to the corresponding parts of the pulley.

A friction clutch is one in which the power is transmitted thru two surfaces which are clamped together as above so tightly that the friction between them makes them act as one. In most cases these surfaces are lined with some non-metallic substance.

A jaw clutch is one in which the power is transmitted thru interlocking "jaws," which are large offsets or teeth, and are integral parts of the castings. The former is better suited to high speeds and the latter to low speeds. Every machine in a plant should be equipped with a dependable clutch, as it is a safety device, reduces repairs, decreases power and has other advantages.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

139—COAL, GRADES OF.—The following characterizations of the different coals have been suggested by the U. S. Geological Survey, Steam and Cosgrove:

1. Graphite, which is not available for fuel, because of the high temperature required for its ignition.

2. Anthracite, commonly called hard coal, is practically all fixed carbon. It has a deep black color, a shiny, semi-metallic luster, few joints and clefts, and is compact and sometimes iridescent. Its specific gravity ranges from 1.3 to 1.8. It neither softens nor swells when burning. It kindles slowly and with difficulty, and burns with a short, yellowish flame, which changes to a faint blue, and is transparent in appearance, owing to the absence of particles of solid carbon.

3. Semi-anthracite is not so hard nor dense, and lacks the luster of true anthracite. It can be easily distinguished by the fact that when newly fractured it will soot the hand. The specific gravity is about 1.4. Semi-anthracite contains more gaseous matter, and for that reason kindles more readily and burns more rapidly than true anthracite. It makes a very intense, free-burning fire.

4. Semi-bituminous coal is still softer than semi-anthracite, and lacks most of the bright metallic luster, altho it is brighter in appearance than bituminous coal. It contains more volatile hydrocarbon, kindles and burns more easily than anthracite, but resembles anthracite more than it does bituminous coal. It is ordinarily free-burning, without smoke, and has a high calorific value. It is of the highest class for steam generating purposes.

The Common Type-Soft Coal.

5. Bituminous coals are commonly called soft coals. They consist of fixed carbon and bitumen. This is a mixture of hydrocarbons, which, when heated, breaks down into gases, oils, and tars. Bituminous coals have more volatile matter than the preceding classes. The range in specific gravity is from 1.25 to 1.4, and the color from dark brown to pitch black. In hardness they range from lignite to semi-bituminous. The harder varieties have the best heating values.

Generally, bituminous coals are brittle, with a vitreous, resinous or greasy luster. The distinction between semi-bituminous and bituminous coals is important economically; the semi-bituminous coals have about 6% higher heating value per pound of combustible, and burn with much less smoke. Bituminous coals absorb moisture from the atmosphere. The surface moisture will dry out naturally, but the moisture absorbed internally is driven out only at a temperature of 250 deg. F. A distinguishing characteristic is a yellow flame and smoke when burning. There are two types of bituminous coals, designated usually as caking coals and non-caking or free-burning coals. Caking coals are rich in hydrocarbons, and valuable therefore in gas manufacture. They fuse and swell when heated. Non-caking coals do not fuse, but hold their shape, burn much more freely, and are preferable for steam purposes.

6. Sub-bituminous coal is frequently called black lignite, and is not readily distinguishable from either lignite or bituminous coals. Its chief characteristic is a tendency to absorb moisture if exposed to the weather, and to slake like lime. It has a fairly bright luster.

Lowest Grades.

7. Lignite is sometimes called brown coal, and is vegetable matter in the early stages of coal formation. The specific gravity ranges from 1.2 to 1.23. When first mined it may contain up to 50% moisture. The color is light brown, showing a distinct woody structure in the poorer varieties, ranging to black with a pitchy luster resem-

bling hard coal, in the best varieties. It is non-caking, and burns with a slightly smoky flame, with moderate heat. It is easily broken and will not stand handling in transportation. The ash content of lignite ranges from 1 to 50%. It is distinctly a low-grade fuel, but cheap.

8. Peat is organic matter in the first stages of conversion to coal. It is found in bogs. The moisture averages 75 to 80%. It is unsuitable for fuel until dried, and may then contain as high as 30% moisture. Large deposits are found in this country, but as yet are little used.

140—COAL HANDLING EQUIPMENT.—In order to reduce the cost of unloading coal from cars and transferring it to the kilns or boilers, several types of equipment have been put on the market and are very successful. When it is considered that approximately one ton of coal is needed to burn four or five tons of clay products, on the average, it is surprising that not more of these installations are found. Several types have a belt conveyor which fits over the car and unloads into a pile. Another belt loads from the pile into the carts, wagons or auto trucks which haul it to the kilns or boiler room. Large plants find that a crane with a clam shell or orange-peel bucket is very efficient. Several types of coal handling equipment are built in which the coal is dumped into a hopper, from which it is elevated or conveyed into a bin. This bin has chutes or gates by which the coal is taken from the bin and loaded into carts, wagons, and industrial or auto trucks for haulage. For hauling coal and ashes auto trucks show a large saving compared to carts or wagons. Another type of coal handling equipment has cars built like mine cars, which run on an overhead track. The coal is loaded into them at a central point, and they are run along the track until they reach the place where the coal is to be used, and at this point the coal is dumped from the cars. This system is suited to square kilns better than to round ones.

MANUFACTURERS (see catalog section):
Green, L. P.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

141—COAL, HEAT VALUE OF.—The heating value, or calorific value, of a coal is the number of units of heat liberated by the perfect combustion of one unit weight of the coal.

A British thermal unit (B. t. u.) is the quantity of heat required to raise the temperature of one lb. of water one deg. F.; (e. g., from 63 to 64 deg. F.).

The gram calorie (small calorie) is the quantity of heat required to raise the temperature of one gram of water one deg. C. at a mean temperature of 15 deg. C.

The kilogram calorie is 1,000 times the small calorie.

The necessity of knowing the heating value of the coal burned is very important, since the evaporation per pound of coal does not of itself indicate efficiency. For example, if an equivalent evaporation of eight lbs. of water per pound of dry coal would represent 70.5% efficiency of the coal containing 11,000 B. t. u. per lb., the same amount of evaporation with a coal of 14,500 B. t. u. heating value per lb. would represent only 53.5% efficiency.

Two heating values must be considered for fuels containing hydrogen. The heating value found by the calorimeter is higher than that obtained under boiler conditions by an equal amount of the latent heat of evaporation of the water formed by the combustion of the hydrogen. These are called the higher and lower heating values. The higher value, which is determined by the calorimeter, is the only scientific unit, and its use is recommended by the American Society of Mechanical Engineers.

There is no absolute measure of the lower heating value. It is an artificial unit, which involves the ultimate analysis and assumptions that make the unit impractical.

142—COAL, HOW TO SELECT.—Primarily, the clayworker is interested in coal for three specific purposes: (1) to manufacture producer gas, (2) to generate steam, and (3) to dry and burn clay ware. The question of what kind of coal should be used for each of these purposes can only be answered by the peculiar conditions that govern the individual coal-burning installation. Climatic conditions, grate area, nature of draft, method of firing, and numerous other conditions enter into this problem, so that it is possible to make only general recommendations. As a rule, the clayworker and his engineer will find the coal supply merchant and the members of the state geological survey not only willing but very desirous of assisting him to work out his fuel problems in the most economical and satisfactory manner.

Coal for Making Producer Gas.

In the clay industry, the gas producer is mostly used to convert low-grade coals (such as run-of-mine, etc.), lignite, or peat, into gases suitable for burning clay ware. Practically any kind of coal may be used in the producer, however, the range of practice covering all the fuels in the country, from peat to anthracite. The gas produced from anthracite is of a uniformly rich quality, containing merely such impurities as may be successfully removed by a washing process. The most suitable anthracite is a No. 1 buckwheat size, but its cost prohibits its general use in the clay industry.

Coal for Steam Purposes.

For a boiler plant which generates steam for power or drying, semi-bituminous or bituminous coals are generally recommended, their preference being due to the fact that they are more highly volatile than anthracite and therefore burn more readily. With these coals, once the gaseous matter is consumed and the additional heat given quickly to the boilers, the remaining fixed carbon of the coal maintains the even supply of heat. The method of firing should always be such that the gaseous matter, which is evolved quickly when the coal is thrown on the fire, will be thoroly mixed with the proper proportions of air to insure rapid and thoro combustion; otherwise, the possible loss of energy from the use of such coals may run into costly figures. For this reason, the use of mechanical stokers, together with a forced draft, is advisable wherever the size of the clay plant involves the consumption of great quantities of coal. For generating steam, inferior coals, running high in ash or bony coals, can often be used with success where ample grate area is provided, especially when fed by a mechanical stoker.

The relative value of coals for steaming purposes depends so largely upon the method of usage, equipment, etc., that little dependence can be put in the comparative records of the fuels, unless all the conditions such as grate area, draft supplied, rate of demand, etc., are well understood.

It may be safely stated that a decision on the fuel to be used is a prerequisite to the selection of boilers.

For example, if anthracite coal is used there will need to be a larger grate area than if bituminous coals are used. The conditions of service should also be understood, so that if fluctuations in steam demands are anticipated these contingencies can be successfully met.

Coal for Burning Clay Ware.

For burning coarse brick in kilns, a coal high in volatile matter and producing a flame of long length is required, so as to penetrate thru the kiln and insure uniform burning. Non-caking gas coals are especially suited for this purpose, altho almost any coal sufficiently high in volatile matter and calorific value will suffice, as sulphur and other impurities in the coal are not of great importance, other than in the amount of ash and clinker formed.

In the burning of building brick, sewer pipe, terra cotta, fancy tile, glazed ware, etc., entirely different conditions create altogether different requirements, since coal for these purposes must be as free as possible from impurities that tend to mar or discolor the materials being burned. The coal should be low in sulphur, as the sulphurous fumes may form sulphuric acid, which unites in the kiln with the bases of soluble salts to make sulphates, causing white spots (kiln-white) to appear on the surface of the ware. (See Soluble salt.) This class of coals should also be low in ash content, especially if the ash clogs the grates with clinkers, necessitating frequent cleaning, with the consequent danger that the fine ash will be carried into the kiln by the kiln-draft and deposited on the surface of the ware. Clinkering coal is particularly objectionable where flat grates are used. Coal of this variety will often cake upon the grate to such an extent that shaking is impossible, and removing the clinker is possible only by the use of slice bars or hooks. In dead bottom furnaces a clinkering variety of coal may not be objectionable.

143—COAL USED BY CLAY PRODUCTS PLANTS.—The U. S. Department of Commerce reports the amount of coal used by 341 industries. In this report the clay products industry ranks third, being surpassed by only the coke industry and the iron and steel industry.

If the figures for the first fifty-nine industries on this list are omitted for the time being, it will be found that the clay products industry uses more than the total consumed by all of the remaining 282 industries.

Interesting statistics have been revealed in a questionnaire filled out by a large number of clay plants representative of the central district of the United States. Out of 138 who replied as to their annual coal consumption, 23 used less than 1,000 tons; 43 between 1,000 and 5,000 tons; 29 between 5,000 and 10,000; 10 between 10,000 and 15,000; 19 between 15,000 and 25,000, and 14 used over 25,000 tons of coal annually. The total annual tonnage used by these 138 factories amounts to approximately 1,245,000 tons. This means that the average annual tonnage consumed by a clay plant amounts to approximately 9,022 tons, or about a car load a day for each day that the average plant operates.

Of the kind of fuel purchased, 39 use mine run; 6, screenings; 27, lump; 17, egg; 20, nut, and 8, gas.

The approximate annual consumption of coal in the clay products industry is as follows:

Ohio	3,500,000
Illinois	2,000,000
Pennsylvania	1,500,000
Indiana	800,000
Iowa	600,000
New Jersey	590,000
Missouri	550,000
Texas	375,000
Tennessee	375,000
Kansas	360,000
New York	350,000
California	270,000
Georgia	225,000
Kentucky	225,000
West Virginia	200,000
Minnesota	170,000
Arkansas	160,000
Michigan	120,000
Total	15,000,000

COLORING MATERIAL, BRICK, see Manganese oxide, Barium carbonate, and the two entries under Iron.

COLORING MATERIALS, see Decorative coloring metals; also Glazes.

COLORS, OVERGLAZE, see Decoration, overglaze, etc.

COLORS, UNDERGLAZE, see Decoration, underglaze, chemical composition of colors used.

COMPOUNDS, BOILER, see Boiler compounds.

COMPOUNDS, WIRE ROPE, see Wire rope compounds.

COMPRESSED AIR, see Air compressor.

144—COMPRESSION.—A term used in pottery manufacture to designate the method of making any ware by pressing the top part of the mold onto the lower part. It is used principally for flat ware, for hand made roofing tile, etc. There must be some provision for allowing the excess of clay to escape between the two layers of the mold. In use a piece of clay a little thicker but a little smaller than the required finished piece is placed on or in the lower part of the mold and the upper part pressed down thereon. There must be an excess of clay even tho a small excess because otherwise the mold would not fill out and the ware would be a loss.

145—CONCRETE.—Is the artificial stone made by mixing certain proportions of cement and clean sand with clean aggregates, which can be gravel, broken or crushed stone, crushed brick, pottery, etc. It has been found that if the aggregates have sharp edges the resulting concrete will be stronger than if the aggregate has round surfaces. For foundations that are under water and that must set under water natural or hydraulic cement is satisfactory; but for all work above the water line portland cement is usually used. Where accurate measurements are required the proportions should be mixed by placing each in a box of the required size and in filling it level full. Where the proportions need not be so exact mixing by wheelbarrows is satisfactory. If the work justifies the expenditure a concrete mixer will be found to be very satisfactory, as it turns out good concrete in much less time and with much less expense for labor. When concrete is mixed by hand it should be turned by shovels four times, twice when dry and twice when wet. The proportions of cement, sand and aggregate will vary with the different conditions but on an average a mixture of one part of cement, and three parts of good clean sharp sand to six parts of aggregate will be found very suitable. The theory is that enough sand should be used to fill the voids or spaces between the pieces of aggregate. If the sand or aggregate is not clean these proportions should be changed in order to add enough cement to make up for the loss in strength that will result from the admixture of these particles of dirt. The proportion of cement and water can best be judged by the way the material tamps in place. For making wheel roads, walks, etc., the foundation should be made up the same as for a foundation of a building or machine, and the top or wearing surface should be not less than three-quarters of an inch in thickness. This should be made of one part of cement to two parts of clean sand, and mixed wet enough to require no tamping, and at the same time wet enough to be pulled into place with a straight edge. This top surface should be put on fifty minutes after the base is laid.

146—CONDENSER.—A condenser is a part of the equipment of the boiler or engine room. Its function is to condense the exhaust steam into water to be used again in the boilers. There are several types based on the method used in condensing. Two of the most generally used are the jet condenser and the surface condenser. In a jet condenser the exhaust steam is pulled thru a jet by a force of water, and the steam condensed thereby. In a surface condenser the steam is condensed by contact with water or with a surface of metal which is cooled by water. Much greater efficiency of the boiler results from their use, and a consequent saving of fuel naturally follows. The water returning to the boiler from the condenser has a temperature very near 212 deg. Fahr. or boiling point. A small amount of fuel turns it into steam again.

146A—CONDUCTIVITY.—This term is used to indicate the property possessed by clay ware to transmit heat from one piece to another thru contact. This property is valuable in transmitting heat during the burning process. The rate of conductivity is the rate at which a clay will transmit one gram calorie per square centimeter of surface thru a thickness of one square centimeter per second per deg. C.

On the basis of this unit of conductivity the following constants have been determined:

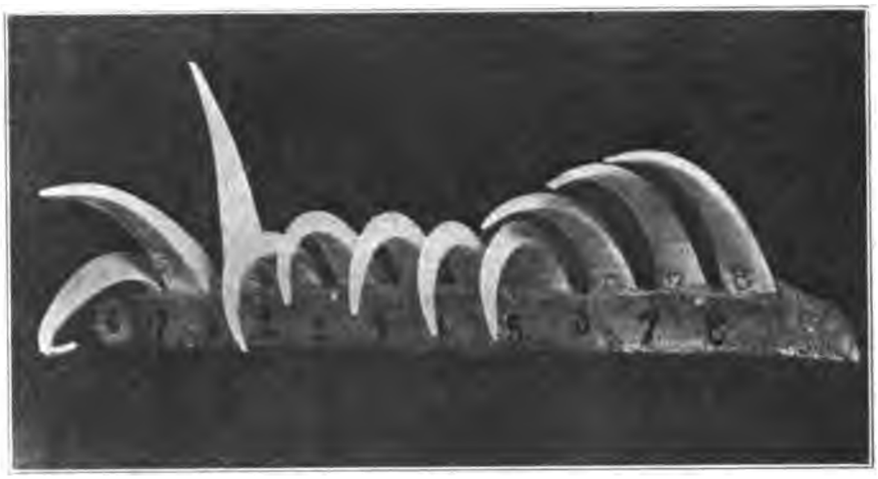
Fire brick	.003 to .004
Floor tile	.004
Vitreous clay	.0045
Diatomaceous earth	.0018

(See tables on conductivity in statistical section.)

147—CONDUIT.—These constitute a special line of hollow blocks of varying length, having sometimes several cross-partitions and rounded edges, and are used as pipes or containers for electrical cables and wires when the latter are laid underground. Because of this condition, the conduits must be hard burned with dense body, and salt-glazed.

The clays used are similar to those from which fireproofing is made, and are prepared in essentially the same manner as for hollow blocks, being molded in augur stiff-mud machines; but they are more carefully selected with regard to plasticity and freedom from pyrite and limonite lumps. In addition, they must burn dense at a moderate temperature.

148—CONES, PYROMETRIC.—Seger cones afford a direct means of measuring the degree of heat required to burn or to melt a given clay. They are really heat measurers rather than thermometers, that is they measure the effect of heat upon clay. Technically, they are better called pyramids, or tetrahedra, for they are really small triangular pyramids with substantially flat bases. They consist of a series of mixtures of clays with fluxes, so graded that they represent a series of fusion-points. They were originally introduced by H. Seger, a German ceramist. The materials he employed were such as would have a constant composition, and consisted of washed Zettliz kaolin, Rorstrand feldspar, Norwegian quartz, Carrara marble, and pure ferric oxide. Seger's Cone 1 melted at 1150 deg. C. (2102 deg. Fahr.). At each successive number above that the temperature was increased 20 deg. C. (36 deg. Fahr.), until the highest number, Cone 39, was reached, which melts at 1910 deg. C. (3470 deg. Fahr.). Following Seger's experiments, Cramer, of Berlin, obtained a new series of lower numbers by mixing boracic acid with the materials named above; and Hecht obtained still more fusible numbers by adding both boracic acid and lead in proper proportions to the cones. As a result there are now 61 numbers, ranging from Cone 022, which has a fusing point of 590 deg. C. (1094 deg. Fahr.) to Cone 39 (see fusing point above).



Result of Burn Showing Heat Equal to Cone 7.

In actual practice, Seger cones are placed in the kiln at a point where they can be watched thru a peephole, but at the same time will not receive the direct touch of the flame from the fuel. Usually, two or more cones of different numbers are put in the kiln; in this manner they may be used to show, first, how rapidly the temperature is rising, and, second, when the end-point of firing has been reached.

Seger cones are used extensively by foreign manufacturers of clay products, and their use in this country is increasing. For practical purposes, where certain reasonable precautions are taken to insure their proper use, they are very successful. (For composition and fusing-points of Seger cones, see statistical section.)

CONVECTION, see Kiln, intermittent, round down-draft.

149—CONVEYING MACHINERY.—This class includes all types of mechanical equipment, except cars, that are used to transport any kind of material from one point to another (see various items under Conveyors, Elevators, Ash-handling equipment and Carriers, gravity).

MANUFACTURERS (see catalog section):

Clearfield Machine Shops.
Freese, E. M. & Co.
Green, L. P.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Philadelphia Drying Machinery Co.
Schaffer Engineering & Equipment Co.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

Schaffer Engineering & Equipment Co., 2828 Smallman St., Pittsburgh, Pa. We are engineers, specializing in the handling of materials.

Webster Manufacturing Co., Chicago, Ill. For nearly half a century, Webster has designed and manufactured elevating and conveying machinery, which has solved many complex material handling problems. In that period of time, we have worked up numerous combinations of speed and capacities which will exactly meet the specific need of your plant. Our engineers, who have had years of successful experience in designing material handling equipment, are at your service. We design and build: Apron Conveyors, Scraper Conveyors, Belt Conveyors, Screw Conveyors, Bucket Elevators, Pivoted Bucket Carriers, V Bucket Elevator Conveyors, Screens, Feeders, Weigh Hoppers, Coal Crushers, Sprockets, Gears, Chains, Coal and Ash Handling Systems.

150—CONVEYOR, AUTOMATIC TRIPPERS FOR.—In using belt conveyors for clay, coal, etc., it is often desired to dump material into different bins at different times. The conveyor usually passes over the entire series of bins, and an automatic tripper is provided to arrange to dump the material wherever desired. It consists of a frame mounted on four wheels which runs back and forth on a track. This enables it to be set at any point. On this frame are two pulleys placed almost directly above one another, and the conveyor belt travels over the top one, and then around the lower one, describing an S in doing so. The top pulley acts just the same as the pulley at the head of an elevator, because as the conveyor belt goes over it the clay, coal or other material leaves it on account of centrifugal force and is caught by a chute which slides it into the bin desired. Automatic trippers are also used for loading cars of ground fire clay and similar products, and if the conveyor is long enough any number of cars can be loaded without moving a car. (See also Conveyors, belt; Storage bins.)

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

151—CONVEYOR, BELT.—The belt conveyor is simply a continuous belt of canvas or rubber on which the material to be carried is placed and either discharged over the head pulley or, at intermediate points, thru a specially designed tripper or unloader. In order to increase the carrying capacity of the belt and to prevent spilling, the edges of the belt are turned up by some form of troughing rollers, which are generally spaced on 5-ft. centers. The return belt is supported below the carrying belt on flat rollers, usually spaced on 10 to 12-ft. centers. On long belts, it is necessary to place guide rollers at the edge of the carrying belt, usually at intervals of 30 to 50-ft. centers, to keep the belt traveling in a straight line. Because the material is actually carried on the belt, it is possible to operate this type of conveyor at a higher speed than any other type of mechanical carrier, and thereby to obtain relatively greater capacities. (See also Take-ups, belt.)

MANUFACTURERS (see catalog section):

Bonnot Co.
Caldwell Co., W. E.
Clearfield Machine Shops.
Freese, E. M. & Co.
Gandy Belting Co.
Goodyear Tire & Rubber Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
New York Belting & Packing Co.
Steele, J. C. & Sons.
Stevenson Co.
U. S. Rubber Co.
Webster Mfg. Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

Cougar Brand Conveyor Belts made by Goodyear Tire and Rubber Co. are confidently recommended for the brick and clay industry. Their balanced construction of body, edges and cover meets the requirements of conveying heavy, abrasive and often damp material. They stand up to the reverse flexing action that so quickly destroys ordinary belts. They are impervious to moisture, and subject to a minimum of stretch and shrinkage. Their efficiency is demonstrated in low-cost-per-ton performance.

152—CONVEYOR, BRICK.—In handling unburnt brick, belt conveyors are used, and in elevating any clay ware to an upper floor chain elevators with small platforms or flights are best. Brick conveyors, however, are considered to refer to the conveyors used to transport burnt brick. There is a conveying system in which a chain travels a regular route supported at intervals by sprockets. From this chain are hung baskets or frames holding four or six brick. The men put the brick into these frames or baskets at one point, and they are conveyed to some other point where other men take the brick out and place them in a car or on a pile.

See Carriers, gravity.

MANUFACTURERS (see catalog section):

American Equipment Co.
Clearfield Machine Shops.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

152A — CONVEYOR, BUCKET. — A bucket conveyor is any type of conveyor or elevator that uses a bucket as a means of moving or elevating any coal, ashes, clay or other material. A bucket conveyor may be of two types one in which the buckets are fastened to a belt as described in the item headed Elevator or bucket conveyor. Also under Conveyor, chain, is described a bucket conveyor using a chain or chains for fastening the buckets into a conveyor.

MANUFACTURER (see catalog section):

Link-Belt Company.

153 — CONVEYOR, CABLE. — These consist usually of a series of iron flights, fastened to a cable. The flights follow a trough as the cable is pulled along in its travel. A cable conveyor is really a drag-plate conveyor where the belt is replaced by a cable. They are suitable to moving coal, clay, cinders and other raw materials. (See also Aerial tramways, Conveyors, drag-plate).

MANUFACTURERS (see catalog section):

Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

153A—CONVEYOR CHAIN.—A chain conveyor is one that uses a chain as the medium for transmitting power or the medium onto which the buckets, drag-plates, flights or other attachments are fastened.

Monorail Conveyor Handling Clay Products.

The chain used is the regular chain as used in chain drives, and fits around sprocket wheels at each end of the conveyor. Special links that are of the same general shape as the drive links, but provided with attachments for fastening the buckets, plates, or flights are placed at the points desired. These special attachment links can be of any shape as long as the main part of the link or the part necessary for fitting around the sprocket wheels is of the required shape. (See also Elevator or bucket conveyor; Conveyor, cable.)

MANUFACTURER (see catalog section):

Link-Belt Company.

154—CONVEYOR, DRAG-PLATE & BUCKET.—The drag-line and bucket conveyors are simply modifications of the belt conveyor, but designed for lifting goods at a more abrupt angle than would be possible with a plain belt. In the drag-plate conveyor the width of the belt is greatly reduced, and a chain or metal rod frequently substituted to obtain added strength and durability. To this belt or chain a series of iron or wood plates is attached at right angles to the direction of travel, and on the lower side. In size, they are designed to fit loosely into the metal or wood trough that forms the runway, so that when the conveyor is started, the plates move forward and carry the goods along with them to the top, where the plates pass over the pulley and return to the working plane for further duty. The objection to the drag-line conveyors is that it is apt to stick fast, if the clay becomes wet by exposure to the weather; also that the amount of friction developed by the scooping action of the plates results, first, in an excessive use of power, and second in the tendency to contaminate the clay with the material of which the trough is composed.

Bucket conveyors or elevators are used largely for crushed clays. (See also Elevators.)

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Stevenson Co.
Webster Mfg. Co.
Weller Manufacturing Co.

155—CONVEYOR, HEAVY DUTY, MONORAIL TYPE.—The monorail system of handling materials consists primarily of an overhead track carrying a trolley or carriage on which is mounted a hoist for handling a bucket (or some other type of conveyor) of large capacity, from one-fourth ton to three or more tons. Both hoisting and travel may be accomplished by either hand, pneumatic or electric power. Standard I-beam sections are usually employed for the track, which can be equipped with single or multiple point switches, wherever desired, giving great flexibility in a horizontal plane. These switches can be operated from the ground.

Where electric power is used, the hoist and carriage are made in two forms. One form is controlled, both for hoisting and travel, from the ground; with this type the operator walks with the carriage when it travels along the track. In the other form, a carriage is attached to the trolley, and the operator rides in it, controlling all operations from this point. For hand operations, a standard chain-hoist is suspended from the trolley, and the trolley, in turn, is equipped with a chain-operated drive for moving it along the track.

Pneumatic types are practically the same as the hand operated type except that the hoist consists of a cylinder containing a piston and valves are provided for moving the piston up and down according to whether the compressed air is admitted to the lower or upper side thereof. This raises or lowers the load, and the distance that the load is raised or lowered is dependent on the length of the piston.

Where there is a fixed route of travel for transporting heavy materials thru the plant, or where coal, ashes, etc., are handled in great quantities over comparatively short distances, the monorail system offers many advantages. These, of course, from the standpoint of operating economy, should be weighed against the advantages of other forms of mechanical carriers before preference is given either type.

These conveyors are very serviceable in machine rooms for making repairs, machine shops, etc.

MANUFACTURERS (see catalog section):

Clearfield Machine Shops.
Hadfield-Penfield Steel Co.
Link-Belt Company.
Weller Manufacturing Co.

155A—CONVEYOR, IDLER.—In many conveyors especially of the belt conveyor type, there is always more or less trouble with slippage of the belt. This is especially true with a long belt. A great amount of this trouble comes from sudden excessive loading of a belt, and cold weather is also productive of this trouble. Frequently damp weather causes a belt to shrink and when the weather drys up the belt becomes longer.

If the slippage of the belt does not stop the feed of the material onto the belt very serious trouble may ensue and eventually cause an extensive curtailment of production.

In order to obviate any trouble of this kind an idler should be used to insure a continuous and constant operation of the conveyor. The adjustment of the idler to keep the same tautness of the conveyor at all times can be made to operate automatically or it can be adjusted by bolts, weights or other mechanical means.

156—CONVEYOR, PNEUMATIC.—These conveyors are the opposite of suction conveyors; that is, they are contained in pipe or hose the same as suction conveyors, but the propelling force is compressed air in place of suction. They also are suited to transport sand, ground clay, fine coal, ashes, etc.

MANUFACTURER (see catalog section):
Link-Belt Company.

157—CONVEYOR, PORTABLE.—Portable conveyors are of the belt-carrier type or the bucket-elevator type, with such modifications as are necessary to meet special operating conditions.

Portable Belt Conveyor.

The construction of the portable belt elevator is very simple. The frame upon which the troughing rollers, the two end carrier-pulleys and the driving mechanism are attached is made of wood or of flexible steel for channel iron framework. This framework is usually built in sections each 3 ft. long. Thus, a conveyor, originally 12 ft. long, may be lengthened, by the addition of the 3-ft. sections, and the consequent lengthening of the belt, to any desired length up to 60 ft., provided the original framework, power unit, etc., were sufficiently strong to carry their share of the added burden.

Loading Car with Portable Conveyor.

To permit easy shifting of the belt conveyor from one vantage point to another, the framework is mounted on a sturdy truck, fitted with traveling axles and two or four wheels, the design being such that the truck may be easily demounted, if the conveyor is to operate at a more abrupt angle than its mounted position will allow. In some makes, however, demounting is never necessary, unless the conveyor is to be placed on a sloping roof or in some other position inaccessible to the truck. In these types, the conveyor frame is supported by adjustable steel cables, which, in turn, are supported by a special two-masted rigging which rises from the truck shafting. These cables are so positioned and manipulated as to permit the elevation of the belt-carrier to any angle up to 45 deg.

In handling loose materials, the conveyor is equipped with skirtboards, which prevent spillage. Frequently, where brick, hollow tile, etc., are to be handled at an abrupt elevation, steel plates are fitted on the belt at right angles to the direction of travel.

The traction wheels of some conveyors are also mounted on swiveling axles, so that, with the wheels operating in a lateral position, the entire conveyor may be moved back and forth (i. e., from left to right and vice versa) at will; or, by using the truck as a pivot, the loading hopper can be swung around, in a complete circle, and the load discharged at any point desired. The object of the swiveling axles is to give the portable conveyor proportionally the same degree of flexibility as casters give the hand truck.

The portable belt conveyor, according to type, may be driven from the receiving end or the discharge end. Power is usually transmitted by a roller transmission chain, after, of course, necessary gear and chain reductions have been made between the power unit and the driving mechanism, to obtain the largest practical driving leverage with the least tractive resistance.

The power unit generally consists of a gasoline engine or electric motor. In some types, the engine or motor are mounted on the truck. In other types, the motor and driving mechanism are located inside the framework, either at the receiving end or the discharge end of the conveyor.

Where extra heavy loads and severe operating conditions impose great stress on the conveyor, temporary supports may be used to advantage at intermediate points between the receiving and discharge areas. A screw adjustment or belt take-up of some character should also be provided in the machine to eliminate excess slack in the belt. Otherwise, the conveyor will not function at maximum capacity, due to the jerky, sloppy motion of the moving carrier and consequent wastage of power.

The belt conveyor may be hand fed or fed, where convenient, by a gravity carrier, the receiving end being invariably supplied with a hopper, from which the material to be moved is dropped onto the moving belt.

Where the portable belt conveyor operates in kilns, a high temperature belt must be used. This generally consists of a standard four-ply belt, a one-eighth-in. rubber cover, with a two-ply and a one-sixteenth-in. rubber cover on top of that, all built and vulcanized into a solid belt. Consequently, the construction is such that the heat of the carried material has to penetrate thru the two thicknesses of rubber and the two-ply before it can attack and weaken the four-ply belt. With eight or nine men in the car, one man feeding between the two parts of the gravity conveyor, and four or five men in the kilns, it has been found possible to load a car with 24,000 tile in about 2½ hours, and to obtain the same proportional efficiency in handling brick and other materials.

Portable belt conveyors may often be operated in series; that is, to have one conveyor discharge into the hopper of a second conveyor and so on. Where this is done (especially where brick, tile or other abrasive material is to be handled), it is good practice to prevent excessive wear on the "catching" belts by using a simple receiving table, which consists of a flat steel plate just clearing the belt sufficiently to allow the cleats to pass. This table is so hinged that it is always in a horizontal position, irrespective of the angle at which the conveyor is operating. As the brick comes to the head of the second conveyor it is slid onto this table and pushed out of the way by the cleat which had been pushing it up the incline.

Portable belt conveyors, used in conjunction with a self-feeding bucket-loader conveyor, are also being rather extensively adopted for the storage and reclaiming of coal for large power plants, coal yards, etc., and in handling and storing clay in brick plants. In these operations, they supplant large gangs of labor, and, when weather conditions do not permit their usage outdoors, it is a simple matter to transfer them indoors for any available duty.

Portable belt conveyors are usually furnished with belt carriers of 12, 18 or 24-in. widths, and in any desired length from 12 ft. upwards to 60 ft. The capacity varies with different types, but the smallest to the largest will handle approximately 50 to 175 or more tons of earth or clay per hour, 25 to 50 tons of coke, 40 to 80 tons of coal, 75 to 175 tons of cement, and 80 to 195 tons of sand or stone.

Self-Feeding Bucket-Loader Conveyors.

The portable self-feeding bucket-loader conveyor, of the traction type, may be used to advantage practically any place where bulky materials must be handled in large quantities, such as stone, gravel and sand in pit and quarries, shale in brick plants, coal and coke in large factories and power plants, etc. The rated capacity of the various types usually ranges from ½ to 1¼ cu. yds. per min., operating at full capacity.

The unit usually consists of a gasoline or steam-driven tractor, either of the caterpillar or the four-wheeled road-engine type, upon which is mounted a complete bucket-loader elevator, with, say, 24 buckets, spaced about 18 ins. apart, and mounted on two strands of roller transmission chain. The elevator frame may be pivotally mounted on a shaft at the top of the main supporting frame, thus permitting adjustment of the lower end for digging or for swinging the bucket conveyor into a nearly horizontal position for moving or shipping. A worm and worm gear, operated by a handwheel, are used to raise or lower the device.

The roller transmission chains should be machined and hardened and of sufficient strength to provide a considerable margin of safety over the maximum stress under which they are designed to operate.

Power is generally derived from a motor truck type of gasoline engine, with all parts carefully protected, yet easily accessible. Lubrication is a vital factor, and too much care can not be exercised in choosing a machine provided with an efficient lubricating system. Most manufacturers supply full instructions to enable the operator to keep the machine properly oiled and greased, and if these instructions are adhered to, repair bills and avoidable shutdowns will be reduced to a minimum.

The portable bucket-loader conveyor is simple to operate. Ordinarily, one attendant supervises all mechanical detail. One lever controls the movement of the tractor, from right to left, as the revolving disks or the blades or arms of the feeding mechanism burrow into the material to be moved and deliver it to the elevating buckets. Forward and reverse motions, controlled by friction clutches, are made by another lever. A third lever, with one friction clutch, operates the chain of buckets; thus the control of the elevator buckets is independent of the

Loading Truck with Portable Conveyor.

control of the power unit, so that the chain of buckets may be started or stopped without reducing or accelerating the normal speed of the motor. All levers, together with the motor controls, are placed within easy access of the operator.

The discharge spout is also pivoted to permit discharging the material from any side with ample clearance. Special measuring hoppers or screens are furnished when required.

Frequently, the bucket-loader conveyor is used in combination with a series of belt conveyors for carrying and storing coal, shale, etc. This system practically eliminates shoveling and all hand work.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Link-Belt Company.
Weller Manufacturing Co.

158—CONVEYOR, SCREW OR SPIRAL.—This type of conveyor consists of a shaft around which sheet iron is wound in a spiral form and fastened at right angles thereto. When the shaft revolves the spiral piece of sheet iron works as a screw and pushes or pulls the material from one end of the conveyor to the other. The conveyor has a round bottom which allows very little space on the outside of the conveyor. This prevents any of the material from falling back. Screw conveyors can be operated horizontally or on a small angle. They are used successfully for transporting any clay almost any distance. The only requisite is that the lumps be not too large.

MANUFACTURERS (see catalog section):
Clearfield Machine Shops.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.

159—CONVEYOR, SUCTION.—A conveyor working in a pipe or hose by means of suction or vacuum exerted at the end of the pipe or hose. It is suited to transport ashes, ground clay, fine coal, sand, etc.

160—CORNWALL STONE OR CORNISH STONE.—This is the most variable mineral used in whiteware, but the following is the average composition:

$$\left.\begin{array}{l}0.32\ CaO\\0.05\ MgO\\0.62\ KNaO\end{array}\right\}1.34\ Al_2O_3\ 9.7\ SiO_2.$$

A vitrified body made from it does not shrink as much as one made from spar. It also gives a stronger body and warps less than spar does, but causes more trouble from spitting out and blistering. It gives the body a brownish green color under oxidizing, and a creamy translucency under reducing conditions (due to iron content). It is obtained from England.

161—COST ACCOUNTING.—An improved system of bookkeeping which provides an accurate record of all departmental as well as general expenses, and enables the manufacturer to predetermine approximately all future expenses, either on a monthly, quarterly, semi-annual or yearly basis. The system likewise enables the manufacturer to determine the weak points in his organization by an accurate comparison of the costs of all steps in production and distribution, thus permitting him to "weed out" unsatisfactory methods and labor, in the departments which are bearing more than their share of the general expense. Cost accounting likewise provides a satisfactory working basis for determining the price at which an article must sell, either in bulk or in small lots, to make it a commercial success.

162—COUNTERSHAFT.—This is a term used to designate the shafts that are placed intermediate to the main shaft and the machines. Ordinarily the main shaft operates at too high or too low a speed to be able to drive the machines direct therefrom or often the main shaft is not placed exactly right to drive direct. To overcome these difficulties and make the transmission of power more flexible countershafts are installed. The best location for them is hung from the ceiling but often they are placed on concrete pillars, the advantage of the latter construction being that the boxes are more accessible and there is less danger of the shaft getting out of line. When hung from the roof there are many little forces like the settling of the building that are tending to disturb the perfect lineup of the shafting. The use of countershafts is almost entirely restricted to belt drives. (See also Shafting; Pulley.)

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Stevenson Co.

163—COUPLING, SHAFT.—Shaft couplings are attachments which fit onto the ends of shafts to fasten them together, and make them act and rotate the same as one shaft. One type is made rigid in which a casting is key-seated to each end of the shaft and the two castings are bolted together. In this type the bearings must be absolutely in line, as the shaft becomes practically one continuous piece. Flexible couplings are also made in which some strong flexible material, like leather, rubber belting or heavy fabric or canvas, is substantially fastened to each casting by the bolts. The power from one shaft is thereby transmitted to the other. Flexible couplings are useful wherever it is desired to join two shafts that may or may not remain in perfect alignment.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Freese, E. M. & Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.

164—CRANE.—A crane is a machine for raising and lowering heavy weights and for moving them thru more or less limited distances while they are suspended.

A jib crane consists of an upright post which is braced at both the top and bottom, and an arm extending at right angles to this post and substantially supported therefrom. From this arm a hoist of some kind, either a chain block, electric, pneumatic or steam hoist is hung. The travel of a jib crane is limited to the length of the arm, and the load is moved by the movement of the hoist while it holds the load.

A derrick crane is the same as a jib crane except that the center post is built so that it will swing in a circle, thus enlarging its capacity and scope. A locomotive crane is the same as a derrick crane with the addition that it is mounted on a truck containing four wheels and has its own motive power so that it can move from place to place, and have a load suspended while moving. The load is raised, lowered and held by a boom, which is fastened to the bed at an angle.

A traveling crane is one that is placed on a track above ground, and spans a space of ten or 12 feet or more. One rail is placed under each support at the ends. It has a hoisting arrangement similar to a derrick crane, and some means of moving back and forth on its track while the load is suspended. The hoisting arrangement can also move sideways across the crane.

Cranes are used for unloading, handling, moving, setting and reloading heavy castings and machinery. The mechanical brick setting machine is operated from a traveling crane. See Setting machine and Loading machine.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Link-Belt Company.
Toronto Foundry & Machine Co.

CRANE, KILN, see Kiln crane.

CRETACEOUS, see Geological ages.

165—CROCKERY WARE.—A general term given all pottery products made from common clays, but more especially used to indicate the cheaper grades of kitchen utensils.

166—CRUCIBLE MANUFACTURE.—Clays for making assay crucibles are rather common and easy to find, but it is not known what exact quality makes one clay more superior for this purpose than another. The only practical way to tell a crucible clay is to make crucibles of it and test the product. The clay, however, need not be extremely refractory, nor can it be easily fusible. It should not be excessively silicious nor excessively aluminous. It must be worked with plenty of grog or plenty of equivalent, in order to enable the product to stand sudden and severe changes in temperature. The details of manufacture is a special problem that must be worked out for each individual clay. (See also Assay slags; Graphite crucible.)

167—CRUSHER.—Certain clays, especially those containing limestone and other hard minerals, as well as the shales and clay rocks, require preliminary preparation in mechanical crushers of extraordinary strength, in order that the large, hard lumps may be properly broken up and reduced to small, uniformly sized particles, so that the clay, after being crushed and screened, will readily mix with water and so become plastic. See following items under Crusher and also see Pan, dry and Pan, wet.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Eagle Iron Works.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.
Williams Patent Crusher & Pulverizer Co.
Gruendler Patent Crusher & Pulverizer Co.

CRUSHER, BALL MILL, see Ball mill.

168—CRUSHER, GYRATORY.—A gyratory crusher consists primarily of four main parts—lower shell, upper shell, spider and hopper. The hopper encircles the upper end of the top shell, upon which the two-armed spider, usually cast in one piece with a ring, rests. The top shell may be lined with chilled iron or manganese steel sectional concaves. The lower shell, forming a base for the machine, also supports the upper shell to which it is securely bolted. The lower shell is fitted with a removable bottom plate which can be readily lowered for inspection or repairs.

There are two types of gyratory crushers. In the suspended shaft type the main shaft, which carries the crushing head, hangs suspended from the spider at a pivot (or fulcrum) point, while the lower end of the shaft is made to gyrate in a circular or rolling movement by an eccentric, for instance, of the ball and socket type. A bevel gear wheel is keyed to this eccentric, and motion is imparted to it by a pinion, keyed to a countershaft.

The movement of the main shafting controlling the crushing head may be simply illustrated by holding a pencil in an upright position, the top being held firmly, the bottom moving in a circle. Owing to the circular or rolling movement of the crushing head, the material passes continuously from the hopper to the receiving opening between the crushing head and the concaves, and, after it has been crushed or reduced to the required size, falls onto the inclined diaphragm, then into a chute, thence thru the discharge spout to the elevator or storage bin.

Gyratory crushers are built in a wide range of types and sizes, in which the capacities vary from two tons to 1,300 tons per hour, requiring from approximately three or four h. p. to 275-300 h. p. to operate. The materials may be crushed to particles one-quarter-in. in size or as coarse as desired up to nine ins. Different sizes and types of crushers weigh from about 4,000 lbs. to 425,000 lbs., installed complete.

In gyratory crushers of the supported type, the weight and downward thrust of the crushing head and main shaft, and, consequently, the stress of the crushing operation, are carried on a step-bearing at the lower end of the shaft, which is the point of greatest gyration. The design is such, therefore, that the burden is centered at one point within the compass of the eccentric bearing, this principle being the reverse of that employed in the suspended-shaft gyratory crushers. Otherwise, the two types are very similar.

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

169—CRUSHER, JAW.—This type of crusher consists primarily of a cast-iron or steel frame, which houses the driving mechanism and two jaws, one of which is stationary, the other mounted to work on a hinge or pivot. The faces of the jaws are set to work on an angle sloping towards each other at the bottom, thus forming a V-shaped hopper. The movable jaw is actuated in a forward and backward movement by the motion of eccentric or pitman, and thru this jaw the heavy steel drive shaft passes. As the steel jaw is alternately driven forward and backward, the hopper is alternately narrowed and broadened; this allows the rock or clay fragments to progress gradually downward until the crushed particles are small enough to pass the exit opening. Ordinarily, however, one movement of the crushing jaw suffices to break the material into particles of the desired size.

There are numerous modifications of this type, some of which permit adjustment between the two jaws, thus furnishing any desired size of particles. The various models, completely installed, weigh from about 6,000 lbs. to 500,000 lbs., and will crush clay into particles ranging from one-quarter in. in size, upward. The capacities range from about one-half ton to 600 tons of crushed clay hourly. Horsepower consumed ranges from five h. p. to 250 h. p.

Altho normally designed for rock crushing, jaw crushers are used in many clay plants for reducing hard, lumpy clay, shale, etc.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.

170—CRUSHER, ROLL-HAMMER AND SWING-HAMMER.—The roll-hammer crusher is adapted for reducing limestone, shale, etc., into relatively small particles, when lumps can be fed to it in four-in. sizes or smaller. The machine consists of a heavy steel or cast-iron casing, in the lower section of which is a curved grid screen, which acts both as a grinding plate and screen. At one end, the top of the casing is provided with a receiving hopper. Below the hopper is a heavy steel impact or breaker plate. A shaft extends thru the center of the casing. Heavy steel discs are attached to the shaft; and to these discs, suspended from the ends of 12 steel arms, six heavy hammers are attached. These hammers revolve at a speed equivalent to 120 hammers passing a given point each second. As the hammers pass the receiving opening, they catch and hurl the clay or shale lumps against the breaker plate, reducing them instantly to relatively small sizes. The rapid downward movement of the hammers then carries these particles to the grinding plate (really a series of steel screen bars) and completes the disintegration. The particles then drop thru the screen to pit, elevator or conveyor. The grid screen is made in replaceable sections, and is generally adjustable to furnish any size particle desired.

MANUFACTURERS (see catalog section):
American Pulverizer Co.
Gruendler Patent Crusher & Pulverizer Co.
Hadfield-Penfield Steel Co.
Link-Belt Company.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Inventors of the Hinged Hammer & Swing Hammer Crusher and largest exclusive manufacturers in the world of this equipment.

171—CRUSHER, SINGLE-ROLL.—The construction of these machines is very simple, avoiding awkwardness and unnecessary complication of working parts. The crusher, mounted on a heavy cast-iron box frame, contains bearings for a roll shaft and a driving shaft. The box frame contains a crushing roll, provided with teeth or flutes of suitable size to reduce the material as desired. There is also a breaking plate against which the crushing roll works to break down the material; this breaking plate may be of a fixed or adjustable type. In the latter case the distance between the roll and breaking plate may be altered as desired. Single-roll crushers are made in a wide range of sizes, for both portable and stationary installations.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:
Stevenson Co., Wellsville, Ohio. Stevenson Crushers are furnished in a range of sizes that will meet practically any demand. Firstly—they are designed right. Secondly—they are built right, thus assuring you the best machines of this type that can be secured. Several types of roll are offered for customer's choice.
BUILT FOR SERVICE—HENCE—A MEMBER OF THE STEVENSON LINE!

172—CRUSHERS, TWO-ROLL & COMPOUND.—Roll crushers generally consist of two chilled steel rolls mounted horizontally on a heavy cast-iron or steel framework, the slow-speed machines generally being operated by gear drives, and the high-speed by belt drive. The shafts of both rolls may be stationary, in which case the bases of the bearings form a part of the main frame; or one may be stationary and the other movable. In the latter case the bearings of the movable roll are arranged to slide on the main frame to permit the rolls to be set at various distances apart, according to the size of particle desired in the crushed product. The size of raw materials which the rolls will take depends (1) upon the size of the rolls themselves, and (2) upon the distance between the rolls. There are many modifications of this design, including the compound crushers which utilize two sets of rolls, one set being placed directly over the other set, so that, as the crushed material passes thru the top set of rolls, it is fed to the secondary set which completes the crushing operation.

In a crusher having rolls of the same diameter driven at the same speed, breaking up the lumpy or rock-like fragments is done by crushing force alone; but if the rolls vary in size, or if they are driven at different velocities, the clay particles are both crushed, by being drawn between the rolls, and also subjected to the rending influence of friction and rubbing between the clay and roll. This is illustrated in certain crushers wherein a large, slowly moving roll draws in the clay lumps, while a rapidly revolving smaller roll supplies the real disintegrating energy.

In some machines, the rolls are fitted with projections, which tend to knead the clay more or less as it passes thru; these projections may be rows of steel lugs or pins, or a series of knife edges or cutting bars set in the surface of both rolls.

In other types, especially those used for crushing soft clays, the rolls may be faced with corrugations or a winding tread; this system increases the kneading power of the crusher and is effective in removing large lumps or stones from the clay by carrying them along the pitch of the tread and discharging them at one end of the roll.

The conical corrugated crusher operates in much the same manner, being particularly applicable to loamy or glacial clays; the revolution of the rolls carries the limestones or other pebbles toward the end of the cone having the largest diameter, where they are discharged.

A set of average sized rolls, in practically all standard roll crushers, will prepare clay for 25,000 to 150,000 brick (95 to 570 tons) per day, the output depending upon the speed of the crusher, where the clay is of such a nature that it requires no other preparing machinery.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Steele, J. C. & Sons.
Webster Mfg. Co.
Weller Manufacturing Co.
Williams Patent Crusher & Pulverizer Co.

CUP GREASE, see Lubricating oil and grease.

173—CUTTER AND CUTTING TABLE, ALL TYPES EXCEPT ROTARY.—In one type the cutting frame is placed next to the die of the brick machine and the measuring belt at the opposite end. The measuring is done by the column after the clay has been cut but before the brick are separated. The measuring belt drives the measuring pulley, one revolution of which measures the proper length of the column and trips the mechanism which sets in motion the independent power for making the cut and drawing the table back in position. The machine is mounted on a strong cast-iron base, which makes it self-contained and insures alignment. The base is machined and lined with steel tracks for the rollers which carry the cutting frame. The thrust bars can be removed and others substituted for changing the thickness of brick every few minutes. The thrust bar adjustment permits a variation of the column width from 7½ to 10½ ins. The wires are very short, measuring 12⅝ ins. long, the object being to reduce breakage to a minimum. It is also a simple matter to change the wires while the table is in operation. The table is designed to cut brick within 26 ins. of the brick machine die. The machine is equipped with an 18 by 6-in. driving pulley, which makes about 180 r. p. m. Over-all floor space occupied is 13 ft. 2 ins. by 6 ft. Capacity, 5,000 to 8,000 standard building brick per hour. Total weights, 5,500 lbs.

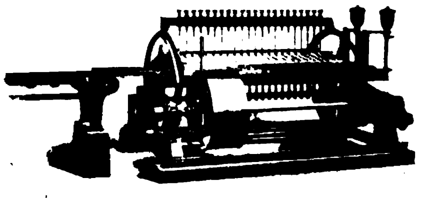


Fig. No. 1. Cutter for Use with Steam Press.

A feature of this type of machine is the right angle delivery; that is, the off-bearing belt connects with a separating belt made up of angle-iron side pieces and cast-iron frames. This separates the brick, before delivering them to the belt conveyor, to facilitate easy handling.

Special models of this type of cutter are capable of making 10,000 to 15,000 side-cut brick per hour. In this size, the length of column cut at each operation is 72 ins., which enables the cutter to have a large capacity with a relatively slow movement.

Semi-Automatic Cutters.

Figure No. 1 shows a semi-automatic cutter for use in connection with a steam press or plunger machine. The machine derives its name, semi-automatic, from the fact that the cutter clutch is tripped by a hand lever. Occasionally it is found advisable to connect the tripping lever to the plunger in such a manner as to convert the cutter into a full-automatic machine. The platens in this type of cutter can be made so as to space the wires any distance apart. The machine will cut

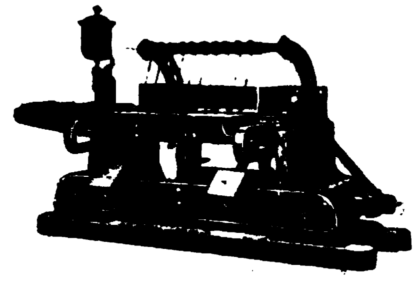


Fig. No. 2. Hand Operated Board Delivery Cutter.

fire brick, block and tile, also hollow ware, and will take a column of clay as wide as 16 ins., as high as 12 ins., and as long as 60 ins. The off-bearing belt is generally furnished in 20-ft. sections. The machine itself occupies a floor space of 9 ft. 6 ins. by 6 ft. 1 in., and has an over-all height, with platen raised, of about four ft.

Down-Cut Board Delivery Table.

The second illustration (see Fig. No. 2) shows a typical down-cut board delivery table, designed for cutting side-cut brick, face brick, fire clay slabs, fire brick, etc. It is hand-operated and has a rated capacity of 2,000 to 3,000 standard size brick per hour, depending upon the ability of the operator. The wires are suspended on a movable cutting frame fitted with rotary wire tighteners. The push board is stationary. The operator stands at the end of the table farthest from the machine, and manipulates the lever by which the wires are drawn thru the bar of clay; the action is such that it gives a clean cut, with one smooth edge and end on each brick. The pallet or board is drawn under the brick while being cut. The cutting is done at the moment when the traveling column of clay abuts against a stopping plate near the operator, which starts the table to move outward with the column of clay. After the cut is made the operator pulls the table toward him, thus enabling the wires to clear the end of the traveling clay column. The back stroke of the lever puts the wires in their original position and deposits the board with brick at the front of the table from where they can be removed by hand.

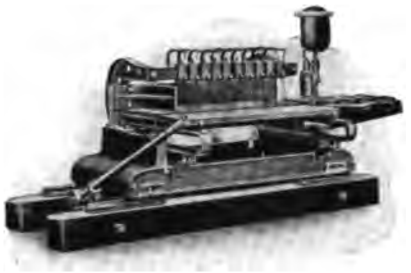


Fig. No. 3. Board Delivery Cutter in Which the Wires Cut Sideways.

The down-cut board delivery table is usually made entirely of iron and steel, with all working parts moving on "anti-friction" rollers. The cut shows a left-hand delivery, but the machine is furnished, by most manufacturers, for either right- or left-hand delivery.

Side-Cut Board Delivery Tables.

The construction and operation of side-cut board delivery table (see Fig. No. 3) very closely approximates that of the down-cut board delivery types. As with the down-cut table, the cutting is done at the moment when the traveling clay column abuts against a stopping plate near the operator, which starts the table to move with the column of clay. After the cut is made, the back stroke of the lever replaces the wires in their original position and deposits the pallet of brick at front of table for quick removal.

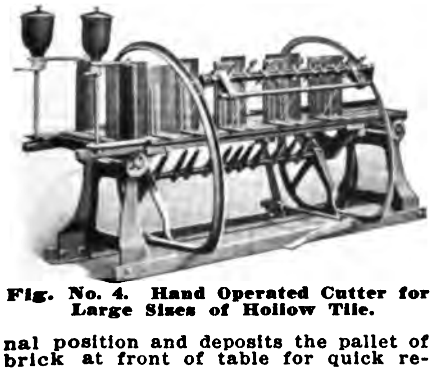


Fig. No. 4. Hand Operated Cutter for Large Sizes of Hollow Tile.

Various makes of side-cut board delivery tables use many different methods of lubricating the clay column to carry it from the die machine to the cutter without excess sticking and smudging of the carrying mechanism and the cutter. In the illustrated type, a short, polished plate, with a lubricating roller at each end, is used in conjunction with a device for oiling the side and bottom of the clay column. The table itself is made of iron and steel, with all working parts moving on compound "anti-friction" rollers. The push board is also so constructed that the back of it is clear, which prevents clay sticking to the wires and clogging. In the illustrated machine, the cutting wires are held at the lower end by lugs and at the upper end by spring bows; in other makes, the tension of the wire is adjusted by means of a coil spring (for example, see arrangement of wires in Fig. No. 1).

Hand Power Cutters.

Fig. No. 4 or last illustration depicts a hand power cutter designed for cutting hollow ware up to 12 by 16 ins. flat, or smaller sizes not higher than 12 ins., e. g., 3-in. by 12-in., 4-in. by 12-in. and 8-in. by 12-in., can be cut on edge. The table is of wood, but metal lined. The side platens are held in position by adjustable cast-iron brackets, making it possible to vary the width between the platens to suit the width of the block being cut. Oil rollers are provided to lubricate the clay column, both sides and bottom, the side rollers being adjustable. With this type of cutter, special top and special side curved platens can be attached to conform to the radial side of the block. An off-bearing table and belt, generally adjustable as to height at the receiving end, are usually operated in connection with this and similar hand power tables for hollow ware.

Other Classes of Tables.

Many manufacturers who supply the clay products industries make a variety of small tables of special design for practically all classes of duty. These are, for the most part, merely modifications of the standardized designs, with no striking difference in mechanical detail or method of operation. They reduce the more intricate mechanism of the automatic and semi-automatic types to the most simple forms of construction for efficacious hand operation.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Stevenson Co.

MANUFACTURERS' ANNOUNCEMENTS:
Freese & Co., E. M., Galion, Ohio.
Automatic clay column reliever—a device installed on an automatic cutter to automatically relieve the column of clay of the work of operating the cutter carriage, thus preventing swelling of the clay bars.
Band brake for automatic brick cutter—gradually reduced speed of cutting reel after clutch is disengaged, stopping it without jar in proper position.
Cone clutch for automatic brick cutter—a cone clutch for operating cutting reel of automatic brick cutter. Allows high speed without undue shock.

174—CUTTER AND CUTTING TABLE, ROTARY, ALL TYPES.—The rotary cutter, in all types, is essentially a quantitative production machine, due to its simplicity of operating detail and flexibility of application. The various designs are now supplied by different manufacturers in sizes rated to meet the requirements of any plant.

Rotary Automatic Cutting Tables.

The rotary automatic cutting table is generally mounted on two heavy I-beams. In some types, the end frames are stationary, being bolted securely to the I-beams or other floor supports, and reinforced with a cast-iron stretcher across the top.

Inside of these frames are the main driving gears for the reel, the frames forming a housing for the gears and protecting them from dirt. The cutting reel has circular cast-iron ends which are supported in their rotary movement on large rollers and the end movement of the reel is also carried on rollers. The reel is provided with four sets of cutting wires and makes a quarter turn at each movement of the table. This motion is controlled by the measuring pulley, which is at the opposite end of the cutter from the brick die. Each revolution of the measuring pulley is equal to the combined width of the platens. Each time the measuring pulley makes one revolution it raises a trip and sets in motion the independent power by which the cutting is done. The reel is drawn back in position for the next cut automatically. The wires move downward in a shearing motion which continues until the wire is thru the column, giving a fine, smooth edge to the brick. Two flexible brakes are provided which stop the reel after each cut, the design being such as to eliminate jar and vibration. The brakes are also supplied with simple adjustment for taking up the wear. In this type of machine the cutting frame operates close to the die of the brick machine, and the measuring belt is placed at the opposite end. This permits cutting the brick within 30 ins. of the die. The cutter can be arranged for any capacity from 3,000 to 10,000 brick per hour. The machine, exclusive of belt, has over-all dimensions of 6 by 6 by 16 ft., and weighs, in the largest size, about five tons. The cutter is belt-driven from a 20 by 6-in. pulley.

In another type of rotary automatic brick and paving block cutter, the rigid end frames are eliminated and the cutting apparatus is simply mounted on a heavy frame constructed of two steel channels, held together by heavy, cast-iron stretchers, with the cast-iron bearing stands for the driving mechanism securely bolted to the floor. The maximum length of cut in this type of cutter usually ranges from 40 to 62 ins., with capacities of 6,000 to 12,500 building brick per hour and 5,000 to 10,000 paving block per hour. Roman brick up to 5 by 13½ ins., hollow blocks up to 8 by 8 ins., and radial chimney blocks up to 7 by 12 ins. are cut with equal facility. The machine can also be used to cut two or three streams of end-cut brick or hollow tile.

In this machine, the cutter is also belt-driven, preferably from an overhead countershaft, which is also used, by a separate belt, to drive the off-bearing table with a quarter-turn drive. In this machine, only two points require, or are apt to need, adjustment; namely, the brake and the locking device. This brake, which is attached to absorb the shocks due to starting and stopping the cutter repeatedly, is fitted with friction surfaces which may be adjusted to suit the degree of wear by simply turning a setscrew. The plate which unhooks the locking device is also adjustable, but in neither case is the wear so severe as to require frequent attention. The measuring belt operates the locking device, which holds the cutter section in position, and which, when released, automatically trips the clutch that drives the cutting reel. There are three sets of wires, which pass thru the column of clay with a downward shearing motion and are automatically cleaned after each cut. As the cutting section moves forward to the end of its travel it automatically engages a gear and pinion, which returns it to its proper position for the next cut, where it is locked and held until the measuring belt trips the locking device. The track under the cutting section is fitted with removable plates to prevent wear on the main castings.

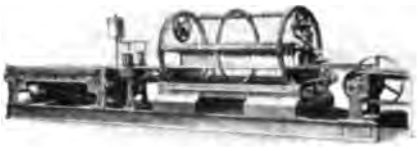


Fig. No. 1. Rotary Side-Cut Brick Cutter.

The power to return the cutting section to position after each cut is obtained from the belt which drives the off-bearing table. The spaces between the measuring belt, cutting section and off-bearing belt are bridged with a steel apron, leaving no gaps for the bar of clay to fall thru.

Modified Rotary Automatic Types.

Some designs eliminate the use of the measuring table by operating the cutter in connection with an expressing machine from which the clay flows intermittently; consequently, the reel carriage does not travel. In other types of rotary automatic cutters the mechanical detail may diverge radically from the above descriptions, but in practically all cases the design will be found to embody the same fundamentals, both as regards construction and operation. This is revealed in figure two, which pictures an automatic table built exclusively for side-cut duty, employing a revolving reel, equipped with arms that carry the cutting wires. In this type, the movement of the clay, assisted by a friction device, imparts motion to the endless belt of the table, adapting itself to the speed of the machine, and insuring a perfect cut whether running fast or slow. The arms that hold the wires are fitted with steel rollers which, in the descent of the wires thru the clay, follow the guides on the endless belt, making a perfectly square cut. The endless carrier, as it moves forward, travels down a curved incline which parts the brick so that the ascending wires do not touch them. A convenient extension at the feeder-end supports the column of clay from the die to the table. Having been cut, the brick are delivered to an off-bearing belt, which, running at a greater speed, separates the brick for handling.

This same principle is applied to the construction of many makes of end-cut brick tables, etc.

Automatic Tile Cutters.

The construction of the automatic tile cutter, built exclusively for that purpose, allows it to be placed squarely in front of the tile machine, and the friction of the clay upon the carrier puts the cutter in motion, and as long as the column of clay issues from the machine the reel turns and the tile will be cut fast or slow, according to the speed of the clay column. The same carriers serve for all sizes of tile up to 8-in., and are easily adjusted. The arms of the reel are not fixed in their socket, but have a given amount of play, and the points between which the cutting wires are stretched are provided with rollers, which meet the iron guides on the carrier belt and carry the wires downward thru the column. The tile carriers can be taken off by simply turning a button on the underside of each, and flat carriers for building blocks installed by the same means.

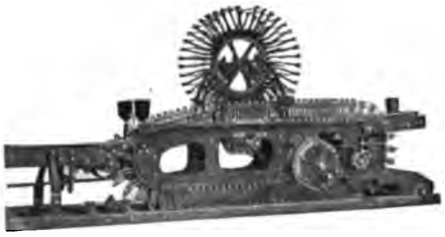


Fig. No. 2. Automatic Cutter for Side-Cut Brick of the Bensing Type.

Rotary Semi-Automatic Tables.

There are numerous types of semi-automatic rotary tables, suitable for practically all classes of cutting. Practically the only difference between them and the automatic designs is that the semi-automatic types are mechanically controlled by two operating levers. One lever operates the pin clutch attached to the driving pulley; this drives the shaft with the two long pinions which revolves the cutting reel. After each revolution of the shaft, which causes one set of wires to pass thru the column of clay, the clutch is automatically disengaged and the cutting reel stops. The second lever permits the operator to assist the bar of clay to move the carriage in correct register with the traveling bar of clay and also to return the carriage to its original position after the cut has been made. The levers are placed at the die end of the machine, enabling the operator to watch the bar of clay and its proper lubrication. The off-bearing table may be driven by a pair of bevel gears.

This type of semi-automatic table may, of course, be obtained in several modified designs, for handling various diameters and lengths of clay columns. Side-cut or end-cut brick, hollow brick or hollow block may be cut by a simple adjustment of the platens.

Hand Power Rotary Cutters.

Hand power rotary cutters are designed to meet the requirements of plants of medium capacity. The operating principle is identical to that of the automatic and semi-automatic types, except the revolving reel is driven by hand leverage. Fig. No. 3 shows the structural details of a recent type, with a rated capacity of 2,500 to 4,000 building brick per hour. The machine may be used for making side-cut or end-cut brick, as well as for cutting hollow brick or hollow blocks when fitted with the proper platens, which are supported on a steel shaft moving with the reel. It will be noted that large cast-iron supporting rings at each end of the reel travel on V-shaped grooved rollers, and that the outer rims of these large rings are provided with teeth which work in connection with the dogs or pawls, similar to a ratchet. These pawls are operated by a horizontal bar. A downward motion of the bar revolves the reel and forces the cutting wire thru the clay column. After each cut, the bar is lifted until the dogs drop into place on the next set of teeth on the ring.

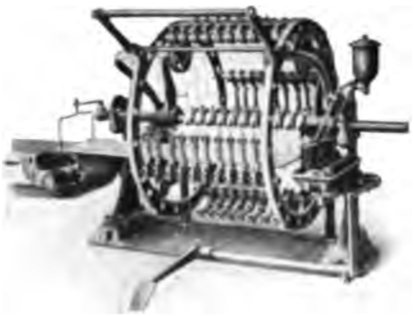


Fig. No. 3. Hand Power Rotary Cutter.

The simplest designs of hand power rotary cutter consist merely of two floor supports, upon which the revolving shaft and reel are placed. The reel contains three sets of wires or two-wires each, and is entirely stripped of all other paraphernalia. The table consists of a number of rollers to support the clay column. This type is adapted for making end-cut brick or cutting tile of 3 to 8-in. sizes, and is very reliable for this purpose.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Stevenson Co.

MANUFACTURERS' ANNOUNCEMENTS:

Freese & Co., E. M., Galion, Ohio. Automatic clay column reliever—a device installed on an automatic cutter to automatically relieve the column of clay of the work of operating the cutter carriage, thus preventing swelling of the clay bars.

Band brake for automatic brick cutter—gradually reduced speed of cutting reel after clutch is disengaged, stopping it without jar in proper position.

Cone clutch for automatic brick cutter—a cone clutch for operating cutting reel of automatic brick cutter. Allows high speed without undue shock.

175—CUTTING WIRE.—This term is applied to all classes of wires used to separate or cut the clay into predetermined sizes (brick, blocks, hollow ware, etc.), as it issues, in the form of a plastic column, from the die molds. Cutting wires vary in length, size and tensile strength, according to the type of machine for which they are designed, but are generally made of No. 18 or 20 gage wire, with a single or double loop at each end, the end strands being both twisted and soldered to insure maximum strength and service. Some manufacturers also give their cutting wires a rust-proof treatment to prevent corrosion and decay during storage. Care in packing is another important factor, as it prevents crooking, buckling and tangling of the wires in shipping and storing.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.

CYLINDER OIL, see Lubricating oil and grease.

D

176—DAMPER, KILN AND BOILER.—A damper is an attachment for regulating the amount of draft. The use of fuel at any point requires a definite amount of air for economical consumption, and except in the case of up-draft kilns the products of this consumption are usually carried off in a stack. Draft is the force which accomplishes this, and a damper is installed to regulate this force. At times a fan is used in place of a stack and the draft can be regulated by the speed of the fan. Too much draft pulls the heated gases out before they have done their work and too little draft reduces the capacity and uses too much fuel to accomplish a certain amount of work. Boiler dampers are sometimes made automatic so that the draft and the consequent consumption of fuel is regulated by the amount of steam used. The use of blowers for forced draft under boiler or kiln often renders the use of dampers unnecessary as the speed of the blower can be regulated. The use of dampers enables the burner to attain the proper burn in every part of the kiln easier than if dampers are not used, and thus he can get more uniform burns quicker and with less fuel. This is especially true of the bottoms of down-draft kilns. For any salt glazing such as sewer pipe or for getting reducing conditions such as are used to obtain the dark colors and flashed effects of present day face brick dampers are a necessity, or at least some method of checking the draft sufficiently. Kiln dampers are discussed at length in the items listed below; Kiln, down-draft, design and construction; Kiln, intermittent, round, down-draft; Draft gage and meter.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Toronto Foundry & Machine Co

177—DECALCOMANIA, CHROMO, OR LITHO TRANSFER WORK.—These terms refer to a common method of decorating pottery, perhaps more generally used than any other at this time. It resembles the printing process except that the design or picture has been made by lithograph process in ceramic colors. Much fine gold border work is now produced by this process. The design is transferred to the ware in the same manner as described under Printing, pottery.

178—DECORATION, AIR-BRUSH.—A method of decoration used in the pottery and terra cotta industries. The color or glaze is applied by forcing a fine jet of colored liquid mixture upon the surface of the ware by means of compressed air. Beautiful effects in light and shade are accomplished in this way, and by means of stencils wonderful results have been obtained. (See also Air-brush.)

179—DECORATION, OVERGLAZE.—After pottery goods have passed thru the biscuit fire, been glazed, passed thru the glost fire, and removed from the saggers, the pieces are again inspected for flaws and any small projections of glaze or adhering pieces of stilts are chipped off by means of steel tools; this makes the ware ready for overglaze decorations, numerous methods being employed for this purpose (see Printing; Decalcomania, chromo, or litho-transfer work; Gilding; Hand-Painting; etc., etc.).

Owing to the much lower temperatures at which they are fixed to the glazed surface, the overglaze pigments permit a wider range of colors than the underglaze decorations; as a rule, the former do not exceed 750 deg. C. (1,382 deg. F.), while the latter may reach 1,300 deg. C. (2,372 deg. F.). Many metallic oxides and combinations may therefore be used which would be volatilized at greater heats. As a result, innumerable overglaze colors have been produced which consist of a colorless flux and the pigment composed of the desired combination of metallic oxides. The flux is prepared from lead oxide and flint, to which borax or boric acid may be added. The simplest combination consists of about 75 parts red lead and 25 of silica. Generally, potters now purchase their overglaze colors ready for use. Overglaze bands are applied to the ware by means of brushes, the pieces being revolved on a decorating wheel. Gold bands are also applied in this manner. After the overglaze decoration has been applied, the ware is ready for the third, or muffle, firing. No saggers are used for this low-fire burn, but the ware is placed on clay or iron supports within a fire clay, vault-like chamber heated on the outside by the hot fire gases, the heat thus being transmitted to the ware almost entirely by radiation. The finishing temperature, not above 750 deg. C. (1,382 deg. F.) is determined by means of base-metal thermocouples, draw trials, or cones. (See also Glaze.)

180—DECORATION, POTTERY.—See the following specific items: Printing, pottery; Decalcomania, chromo, or litho transfer work; Ground laying; Ground laying, wet-process; Decoration, air-brush; Lining; Gilding; Incrustation, pottery; Hand painting; Stamping; Sponging; and Staining.

MANUFACTURER OF EQUIPMENT
(see catalog section):
Mueller Machine Co., Inc.

181—DECORATION, UNDERGLAZE.—This process is used in the manufacture of whiteware; as the term indicates the decoration is under the glaze and must be applied prior to glazing. On the commercial run of ware, underglaze decoration is applied by transferring designs printed on specially prepared thin paper with suitable mineral colors. These transfer decorations may be bought ready for use or printed in the pottery from engraved copperplates. The colors usually are bought in the prepared state ready to be mixed with the printing oil, tho some potters make their own. At times, only the outlines of the designs are printed, the design proper being filled in with hand painting. Bands and lines of various widths are made by means of brushes, the piece being revolved on a small painter's wheel, many of which are provided with a self-centering attachment.

After the application of the design, the latter is allowed to "harden on," which consists principally in the volatilization of the printing oil. This may be done in the decorating kiln (see Kiln, decorative) by firing the pieces to a low red heat. In the case of vitreous ware the hardening on is not necessary.

After glazing, the ware is put on boards and allowed to dry. In English potteries the freshly dipped ware is placed on shelves of a mechanically operated chain conveyor heated by steam pipes (see Mangle, dipper's).

182—DECORATION, UNDERGLAZE; CHEMICAL COMPOSITION OF COLORS USED.—The composition of underglaze colors varies widely, according both to the shades required and the temperature at which the glaze is fused. For the higher temperatures these colors correspond closely to the so-called spinel formula, composed of one molecular equivalent of the alumina with one of the coloring oxide (see "The Collected Works of H. A. Seger," Vol. 11). Thus, an underglaze blue consists of 102 parts of alumina and 75 of cobalt oxide. The mixtures are intimately ground together, calcined to a high temperature, and washed. By grinding with some glaze the underglaze color is prepared ready for use. The compositions of some underglaze colors often used are given herein below:

Pink: Tin oxide, 50%; whiting, 25%; flint, 18%; potassium bichromate, 3%; borax, 4%.

Yellow: Alumina, 8%; tin oxide, 16%; black oxide of antimony, 32%; red lead, 44%.

Brown: Ferric oxide, 18%; chromium oxide, 17%; alumina, 11.5%; zinc oxide, 53.5%.

Victoria green: Chromium oxide, 50%; flux, 50%. This flux consists of 30 parts of flint, 6 of potassium bichromate, 3 of white lead, 3 of whiting and 1 of potassium nitrate.

Blue green: Chromium oxide, 20%; cobalt oxide, 5%; china clay, 27.5%; spar, 27.5%; zinc oxide, 20%.

Blue: Cobalt oxide, 44.5%; alumina, 55.5%.

183—DECORATIVE COLORING MATERIALS.—The preparation of these materials is now done almost exclusively in large plants devoted especially to it. The special methods of manufacture required, combined with the special knowledge and skillful supervision involved in producing pure colors, has made it more economical to deal with a larger quantity of raw materials than is used even in the largest pottery. To secure a uniform color in clay ware decoration, all coloring materials should be finely powdered and well mixed; this grinding is done either by mortars for very small quantities or by the processes used for powdering glazes (see Glaze-grinding machines).

Colors Derived from Metals.

The following list includes only those mineral coloring agencies which are fixed or developed by heat; each paragraph contains the range of colors which may be produced by the specific metal.

Iron.

In relative low temperatures (1,000 deg. C.) and in a slightly oxidizing atmosphere, iron oxide gives a brown or red color, which, if monoxide is present, may become violet or approach black. It is then suspended in the vitreous mass, with which it does not readily mix. At higher temperatures it may enter into combination with the mass and produce unstable colors—such as a bluish-green in alkaline glazes, a brownish-yellow in boracic glazes, and a yellow in plumbiferous glazes. At very high temperatures, ferrous oxide forms silicates which are scarcely colored if only a small amount of ferrous oxide is present, and of a reddish or reddish-brown color if much of it is present. When mixed with certain other oxides, very stable colorings are produced.

Iron oxide in a pure state is obtained by heating sulphate of iron: it then forms a red powder or colcothar, the shade of which depends on the rapidity or heating and the temperature. It may also be obtained by precipitating iron salts by ammonia or by alkalies; in this the shade depends upon the salts employed.

Copper Oxides.

These are used only in glazes which can be vitrified at a moderate temperature. At high temperatures they are inclined to be absorbed by the glaze, and even to penetrate the body itself. With an oxidizing atmosphere, copper in alkaline gives a beautiful azure blue, known as turquoise blue. It becomes intense green in boracic or plumbiferous glazes; but with a strongly reducing temperature it forms the monoxide, producing a beautiful purple-red in alkaline glazes, verging to orange or brown in others. Mixed with other colors, copper oxide makes greens. Copper oxide is particularly used in the form of cupric oxide, a dense black powder obtained by heating nitrate of copper, altho copper carbonates are also used.

Chromium Oxides.

Used only for coloring white bodies, as the presence of iron in other bodies darkens and dirties the colors. Chromic oxide is generally used in glazes. The atmosphere of the kilns is a decisive influence on the color; when the atmosphere is oxidizing, chromic acid is formed; when the atmosphere is reducing, chromic oxide is formed; tho the above action is less marked than with iron or copper, and with a sufficient amount of coloring material present, it results merely in a slight modification of the shades. Chromium oxide in alkaline glazes gives a bluish-green or greenish-blue; but in other glazes it produces a beautiful green color which becomes yellowish with a small amount of oxide in an oxidizing atmosphere. Chromic acid gives intense yellows in alkaline or purely plumbiferous glazes, yellowish-greens in boracic glazes, and in alkaline plumbiferous glazes, at a low temperature, an orange-red color. By mixing stannic acid in a glaze containing lime and a small amount of chromic acid, a red color varying from rose to purple is obtained when the temperature is sufficiently high. The color, in the absence of chromic acid, can be obtained under the same conditions with other substances, but chromium is said to give the best results.

Chromium compounds are also frequently used with other oxides to produce greens with copper, blacks with iron oxide, etc. Chromium oxide is prepared by heating mercury chromate, or by heating potassium chromate with sulphur. Chromic acid is used in the form of bichromate of potash. The use of chromium in pottery began early in the 19th century; its presence may sometimes indicate the date of manufacture of the ware.

Cobalt Oxide.

Has a very powerful blue color, and may be used for coloring either body or glaze; it resists all temperatures. Added to a glaze, it produces an intense blue inclining to violet; light shades cannot easily be obtained pure. When mixed with zinc, it gives ultramarine blue; with aluminum compounds it gives a beautiful sky-blue. It may also be mixed with other coloring oxides to secure various shades of blue.

Cobalt oxide may be obtained from cobalt ores; or it is commercially available in an almost pure state as cobaltous oxide (CoO), as a dark gray powder; but ordinarily cobalt oxide (Co_2O_3) is used which contains 85 to 90% of oxide. For average clay bodies, economy recommends the use of rose-gray cobalt carbonate or the cobalt silicate called rose cobalt, which has about 40 to 50% of oxide. All these cobalt compounds contain some nickel oxide.

Manganese Oxide.

Also a powerful color; mixed with iron, it gives a dark brown or black, and resists any heat applied to the bodies. In glazes, it gives colors varying from brown to violet, according to the amount of iron oxide present and the composition of the glaze. In alkaline glazes it is usually violet; and generally brown in boracic ones. Plumbiferous colors give intermediate colors; and when mixed with considerable iron oxide, manganese compounds produce many browns, and also usually are introduced into the composition of most so-called blacks.

Manganese oxide may be extracted in nearly a pure state from its ores in the form of a black powder. For coloring clay bodies and producing brown glazes the ores themselves are used, after being properly sorted, washed and crushed.

Nickel Oxide.

Seldom used because it produces uncertain and spotted shades, which vary from yellowish-green in alkaline glazes, to dirty green in boracic ones, and brown-green in plumbiferous ones. It is used in conjunction with iron compounds to produce shining browns, and also may enter into the composition of certain blacks.

Nickel oxide is extracted from nickel ores, being a form of green or gray oxide in its free state.

Uranium Oxide.

Produces a yellow color with an oxidizing fire and green or black in a reducing atmosphere. Very costly and rarely used except in plumbiferous glazes, to which it gives, under moderately oxidizing conditions, a very bright orange yellow.

Uranium oxide is derived from pitchblende ore.

Titanium.

Gives yellow tints in glazes, due partly to the iron always contained in a commercial titanic acid.

Antimony Oxide.

With lead, it forms a compound of a yellow color. In all other cases it is colorless but makes other colors opaque. Mixed with iron oxide, it gives a series of beautiful yellows.

Antimony oxide is obtainable in the form of antimonic acid, as an antimoniate of potash, and as antimoniate of lead (Naples yellow).

Gold.

Specially prepared, this metal may be used either as a dull gold, which may be made brilliant by burnishing, or used, directly, as brilliant gold. If introduced into glazes as a chloride, the color varies from rose to purple, resists high temperatures, but is obviously costly. By mixing chloride of gold with chloride of tin, a violet-purple precipitate is obtained, which, in glazes, gives beautiful rose, purple, carmine, or violet colors; but when the temperature is raised above 1,100 deg. C. takes a bluish-violet tinge and often disappears.

Silver Chloride.

Added to glazes, it gives them a yellow color. It is occasionally used for silvering because of the low temperature at which it fuses. It is also frequently added to Cassius purple.

Platinum.

May be used to cover the ware with a layer of dull platinum, made brilliant by burnishing. Added, in the form of chloride, to glazes, it gives a gray color, which resists high temperatures. Very costly.

Iridium.

May be introduced into glazes as an oxide, producing a color varying from gray to black. Rarely used because of its high price.

(Editor's note: The foregoing data were derived from Alfred B. Searle's translated version of "A Treatise on Ceramic Industries," by E. Bourry, published by Scott, Greenwood & Son, London.)

185—DECORATIVE COLORING; METHODS USED.—Coloring materials may be applied to pottery by five separate methods: (1) They may be introduced into the body, which then becomes a colored body, and may, after burning, remain unglazed or be covered with a transparent glaze, as desired. (2) Colored bodies may be used to cover another body with slip, in which case they are termed colored slips, the ware thus ornamented remaining unglazed or being covered with transparent glaze, as desired. (3) The slipped body may be covered with a layer of coloring matter made adhesive by covering it with a transparent glaze (or underglaze coloring). (4) The color may be mixed with the glaze, thus making a colored glaze, either transparent or opaque. (5) The color may be mixed with a flux; that is, made into a vitrifiable color and put on the surface of the glaze, in which case it is called overglaze coloring.

Two or more of these methods may be employed simultaneously. The color itself is influenced by four distinct conditions: (1) By the kiln temperature. (2) By the kiln atmosphere—whether it is oxidizing, neutral, or reducing. (3) By certain colorless materials in the clay bodies, glazes or flux. (4) By the reciprocal action that colors have on each other, the color-mixture not necessarily being a combination of the color of the ingredients; this is illustrated by the variable colors produced by iron oxide in the body and the alkaline, boracic or plumbiferous nature of the glazes.

Thus, in pottery manufacture, a narrow classification of colors is impossible, as they can not ordinarily be made lighter or darker simply by adding white or black to them; but each color must be considered independently in order to obtain the exact tone required. This is done by varying the proportion of coloring matter to a definite quantity of body glaze or flux; or in some cases by varying the thickness of the colored layer.

186—DECORATIVE MOLDING OF CLAY BODIES.—This class of molding has two objects: (1) to create a unique or ornamental object; (2) to decorate objects manufactured by industrial molding.

The molding of an original decorative piece of pottery must be modeled by hand, or done by forming it on a potter's wheel and finishing it by turning, the processes employed depending on the nature of the material and the design of the piece.

Modelling by hand needs somewhat plastic clays, especially for terra cotta and stonewares, and usually for faience. Porcelain bodies are much less plastic and present such difficulties that agglutinants (such as size, dextrine, etc.) must often be added to them.

It is frequently convenient, sometimes necessary, to mold the parts in high relief individually, and to join them to the main object afterwards. This method makes possible the modelling of extensively under-cut objects; also those with thin, delicate raised pieces.

The amount of moisture the body contains is of prime importance; thus, during the period of modelling, the body is kept from drying by the application of wet cloths or sponges. This inconvenience can be avoided when the body can be allowed to harden and then carved. In lean bodies, carving largely replaced modelling, since the pieces can only be formed more or less roughly in the first place. In this manner very thin parts in high relief may be attached, which would lose their shape if put on when the ware is still plastic.

Objects having thick massive parts with other parts that are thin and delicate cannot readily be dried and fired, so that it becomes necessary to hollow out the more bulky parts inside. In this case, after the modelling is done, the part to be hollowed out may be taken off in two or more pieces by a metal wire or with a thin blade. Each part is then hollowed out separately, the whole stuck together again, and the joints cleaned off. As all bodies shrink (about 10% in plastic bodies) during drying and firing, care is taken to increase the original dimensions proportionately. Frequently, it is easier to mold certain ornaments or other parts that are highly raised separately, and later to join or stick them on the main body. This method is very convenient for molding little figures in high relief, also for wreaths and medallions used to ornament the ware.

Decoration by hollow designs, frequently repeated, are sometimes made with stamps having the design cut in relief. In this case, a slab of paste is prepared, the design is formed by the stamp, trimmed, and pressed against the body when it is slightly firm. When the decoration is to form a band in which the design is constantly repeated, the stamp is replaced by a revolving wheel. These two processes are called stamping and beading. Engine-turning (or dicing) may also be used. Large plaques may be decorated by a design repeated indefinitely, by passing them under an engraved cylinder.

When the body is nearly dry, the surface may be polished and its hardness increased by rubbing it with a horn.

Sometimes the glaze forms a part of the molding of the body; this makes possible the formation of plaited objects which would easily break if fired direct; the dipping glaze before firing makes them strong and fastens the pieces together. Small hollows may likewise be made in the body and later filled with glaze, thus creating a special style of decoration.

187—DEFORMATION EUTECTIC.—That proportion of the ingredients of a mixture, which will cause the mixture to change from the crystalline to the amorphous state at the lowest temperature. This is largely used in porcelain manufacture.

DEHYDRATION, see Burning, dehydration period of.

188—DENSITY.—A term used to denote the relationship between the volume of a given mass and its weight, or between the weights of equal volumes of different substances. It is also used somewhat loosely at times in the sense of being opposite to porosity. The density of a clay may be expressed in three forms, referring to clay (1) in its green state, (2) in its fired state, and (3) to the density of a clay slip. (See also Specific gravity, and Porosity.)

To find the apparent density, or specific gravity including pores, of a lump of fired clay, or other material, not affected by water, the piece is weighed on a delicate balance in the ordinary manner, after which it is dipped in melted lard, paraffin or similar material to cover up the pores; the coating of fat should be as thin as possible, so as not to affect the results. It is allowed to cool, and the piece is then hung from the arm of the balance by means of a hair or fine piece of silk of negligible weight. It is reweighed and then completely immersed in water contained in a small vessel. When the balance swings evenly the piece is weighed in this position; then

$$\text{sp. gr.} = \frac{\text{ordinary weight in air.}}{\text{loss of weight in water.}}$$

If preferred, Method 1 (below) may used, when sp. gr. of whole piece=

$$\frac{\text{weight dry}}{\text{wt. soaked—wt. suspended in water.}}$$

To find the true specific gravity of the substance itself (excluding pores), one of two methods may be used:

1. Find the ordinary weight of the piece, then soak it in water for several hours (preferably under pressure) and find the weight of water absorbed (see Absorption,) in grams. This will give the approximate volume of the pores in cubic centimeters (the result will not be strictly accurate, as some pores may be so constituted that water will not enter them; and if these are to be included the material must be ground to an impalpable powder before its specific gravity is determined). Then weigh the piece suspended in water as above described and find the loss of weight. Then sp. gr. of solid=

$$\frac{\text{weight dry}}{\text{weight dry} - \text{weight suspended in water.}}$$

In the case of unfired clay, water cannot be used for soaking the material; paraffin or xylyl should be substituted, and the numbers obtained for the "liquid absorbed" and for the "loss of weight in liquid" divided by the specific gravity of the liquid itself. Or the following method (2) for powders may be employed:

2. To find the specific gravity of a powder, a bottle is weighed empty and dry, then it is exactly filled with water to a mark on the neck and weighed again; the increase in weight gives the weight of water held by the bottle. The bottle is again emptied and dried and nearly filled up with the powder and again weighed; the increase shows the weight of the powder used. The bottle is now filled up to the mark with water and weighed once more; the increase between this and the previous weight shows the amount of water-filled space not occupied by the solid. Hence, sp. gr.=

$$\frac{\text{weight of solid}}{\text{weight of water to fill empty bottle} - \text{weight of water occupying space not filled by solid.}}$$

To find the specific gravity of a liquid, whether a clear liquid or a slip, weigh a dry empty bottle or flask, fill it to a certain mark on the neck (or, if a pycnometer is used, fill it completely) with water at a temperature of 60 deg. F. and weigh again. Increase in weight=water held by bottle. Empty out the water and dry and refill the bottle with the liquid, or slip, and again weigh so as to find weight of liquid. Then—

$$\text{sp. gr.} = \frac{\text{weight of liquid}}{\text{weight of water.}}$$

It is important that liquids be as near 60 deg. F. as possible, as specific gravity diminishes with increased temperature.

To find the density of a clay slip in ounces per pint, multiply the specific gravity by 20; thus, specific gravity 1.30=26 ozs. per pint; and, conversely, the density in ounces per pint divided by 20=specific gravity; i. e., a slip weighing 27 ozs. per pint has a specific gravity of 1.35.

DEPARTMENTAL CALLING SYSTEM, see Signalling system or calling device, interdepartmental.

189—DEPRECIATION.—Depreciation is that phase of accounting which aims at arriving at the loss of value of machinery, land, buildings, or equipment, due to wear and tear of use. Depreciation in the value of clay land can easily be figured rather closely by determining the amount used, but the depreciation in other equipment usually must be estimated. Where proper repairs are made brick buildings usually are figured as having a depreciation of 5% annually. Machinery very seldom can be figured at lower than 10%, and this figure is also the average for a well constructed periodic kiln. Continuous kilns should be figured at a lower depreciation. Tools, wheelbarrows, dryer cars, and similar equipment usually have a high rate of depreciation. At one time a uniform rate was used for every part of a plant but that has been shown to be erroneous and inaccurate. See also Obsolescence. In past years the failure on the part of clay products manufacturers to figure depreciation and obsolescence before arriving at the annual profits has caused many plants to show larger profits than were actually earned.

DERRICK, see Crane.

DEVONIAN, see Geological ages.

DIATOMACEOUS EARTH, see Kieselguhr.

191—DIE, BRICK.—Almost all auger brick machine dies are lubricated, as few clays will run out of a die without pulling back on corners and consequently weakening the brick, if not lubricated. There are quite a few types of dies all of which have advantages and are suited to one type of clay or another. The lubricating medium is oil, water or steam. In some cases the dies are made of plain cast metal and in other cases there is a lining of sheet iron or other material on the inside of the main casting in order to facilitate the equal distribution of the lubricating medium. See also Die, factors of operation.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:
Freese & Co., E. M., Galion, Ohio. Adjustable brick die—a stiff mud brick machine die so constructed that the size of clay column can be adjusted to give the desired cubical contents to the brick.

192—DIE, DRAIN TILE.—In making drain tile only one core is needed. In the old type of machine the core turned as the column of clay came out of the machine. This has now been obviated, by making the auger shaft hollow, fastening the core to a long rod which fits thru this shaft and then using a pin to prevent the core from turning. As a result, automatic cutters can now be used. In making drain tile on a steam press the core must be fastened to a bridge. A bridge is also used on an auger machine in some cases. Practically all drain tile dies are made non-lubricating. See also Die, factors of operation.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

192A—DIE, FACTORS OF OPERATION.—All hollow ware was formerly made on sewer pipe presses, which gave a perfectly equal flow of clay over the entire surface of the die, and made them ideal hollow ware machines in this respect. Their operation depended upon the action of a plunger, however, and their drawback was intermittent delivery. With the increased demand for larger capacities and continuous output, the auger machine was resorted to. The fact was soon disclosed that the webs of tile made on the sewer pipe press were of sufficient density for all practical purposes; therefore, previous compression in a tapered machine barrel was unnecessary. It was also observed that in attempting to force the compressed clay thru the limited openings of a tile die, the dies and machines were frequently smashed, an excessive amount of horsepower was consumed, and, most annoying of all, the clay often backed out thru the hopper in preference to going thru the die.

These observations led to the development of the modern auger hollow ware machine. This machine has a straight barrel, generally a continuous screw auger, the pitch of which is constant or increases toward the front, and a force-feed attachment. Sometimes instead of a force-feed a pugmill is attached, serving the same purpose. This machine does not compress the clay in any way except in front of the auger, the latter merely solidifying it and expressing it to the die opening, giving at the same time the greatest speed with the least possible consumption of power.

The difference between the brick machine and the tile machine are often great enough to make the difference between success and failure. While it is true that considerable hollow ware is made on brick machines, yet the troubles encountered in the operation are multiplied many times even when the best equipment is used, and, of still greater importance, the user is losing the benefit of the best findings of expert investigators who are striving to eliminate the troubles of this branch of the industry; for it is obviously impossible to get these men to experiment with machines which experience has proven to be unsuited for the work.

"Outside" Die Troubles.

So many items, aside from die construction and adjustment, enter into this problem, that some experts regard the die almost a secondary consideration. Some clay operators have spent months and wasted many thousands of dollars in experimenting with dies, only to discover that their troubles came from other sources, which were overlooked because they had not been understood.

Again, merely adjusting a die to produce ware that dries and burns safely is not enough; tonnage, or production, is the crying need, and it is therefore necessary to build and adjust the dies so that the greatest possible column speed may be obtained. Many dies which give satisfaction at low speed are worthless when an attempt is made to get tonnage.

There is one item that demands the most careful attention of the clayworker; that is, to see that the auger or main shaft is absolutely central in the barrel of the hollow ware machine. No one can estimate the amount of die trouble that has been caused, and the money lost, thru time consumed in removing and putting on dies, and thru cracked ware, simply because this shaft was not properly located. The experienced tile worker has learned to look for such defects, even in a new machine.

Frequently, the auger shaft on a used machine will be slightly sprung, and this is even worse than having it out of center. It is practically impossible to make ware successfully on a machine in this condition, as the auger changes the line of pressure on each revolution. In the case of the shaft which is not central, the pressure is always released at the point where the circumference of the auger is farthest from the sides of the barrel.

Effect of Speed.

The speed of the machine is an important factor, since a die may be built that will successfully produce ware at the rate of 10 ft. per minute, but if the machine is speeded up to produce 15 ft. per minute, the resultant ware is a dead loss.

When a machine is driven too fast for a die, the latter invariably develops fast and slow areas. Sections of the die which offer least resistance to the clay flow, either thru webs or walls or the location of the bridges, will be fast in proportion to the other sections. In cases which are not bad, the ware may appear good enough to go into the dryer, but it will come out cracked. In extreme cases the column will tear up as it leaves the die (the remedy for this being given in a later paragraph).

In determining the speed at which a machine should be driven, the raw material enters very little into the consideration. Of course, the variation in clays and shales is sufficient to have some effect, but this is not the decisive factor. When a machine is to be driven at constant speed, the most important point is the relation between the size of the largest die—or rather the largest tile which will be made—and the capacity of the barrel of the machine.

When the auger is driven too fast on a large tile, there is not sufficient compression in front of it to give equal pressure over the whole die. This is due to the large amount of openings in the die, permitting the clay to get away comparatively too fast. Practically nothing can be done to this die to eliminate this trouble; but with a slower speed the clay gets a chance to gather between the auger and the die—forming a sort of reservoir—and it is then compressed and flows out evenly thru the die openings.

When a machine which can only be run at one speed is used to make a variety of sizes it is necessary to determine the speed according to the size of the largest tile. Some modern plants have separate units for large and small sizes, thus getting away from the difficulty, but this is not the general rule.

It is obviously impossible to give the best auger speeds, but those most widely used range from 20 to 25 r. p. m., and in rare cases up to 50 r. p. m., altho the latter practice is condemned by the majority of hollow ware manufacturers. The machine or auger speed is another source of trouble with the converted brick machine, since brick machines are nearly always run at higher speeds than tile machines, and unless the speed is lowered for hollow ware, trouble is almost certain to ensue.

Points on Taper of Die.

The taper or angle of the openings of a die presents a most interesting problem in die construction and adjustment; in fact, the speed of the column issuing from any die is regulated by this taper or angle. When the tapered die was first introduced, the idea of the taper was to give a slight compression to the clay before it issued from the die plate. Each manufacturer had his own ideas as to the amount of taper a die should have, depending somewhat upon the clay or shale to be worked. Experience has proven, however, that no set of rules or laws applies to this condition, and that each individual shale or clay requires a separate treatment; that is, each clay or shale mixture will develop its greatest column speed when run thru a die with a certain taper.

In some cases this taper is so slight as to be almost negligible; in others, it is considerable. In order to find the proper taper for any material it is necessary to make a die of some soft material, preferably wood. It should be made with perfectly straight openings and the cores should be of the same material. When put on the machine the column speed should be noted constantly. As the clay wears away the material of which the die is made, the bar will speed up until a certain point is reached—the peak—after which the speed will drop constantly.

As soon as the column reaches the greatest speed, the angle of wear should be noted. Two or three trials may be necessary to determine this point, but once it is obtained it may be worth thousands of dollars a year to a manufacturer. It is important to note that as the taper is increased beyond a certain point the column gets constantly slower. This is a vital consideration for a manufacturer who buys "stock" or ready-made dies. It should be remembered that no taper is better than too much. The increase in column speed from the no-taper to maximum-speed taper is often little or nothing; but beyond the maximum-speed taper the column invariably slows down.

In order to take care of the wear on dies, some manufacturers build them with less taper than is required to produce maximum speed, and thus allow the dies to wear to the proper angle—passing which it is rebuilt or relined.

To make a die exactly right originally would mean that from the moment it went on the machine it would get slower. The slowing down is caused by the wedging effect which is produced in passing the clay thru an opening which is wider at the point of entrance than at the point of exit. The mixture of clay grains and water can be compressed up to a certain point; beyond that point no more compression is possible and the clay wedges as it attempts to pass thru.

Long-Mouth Dies.

The springing of the cores out of position is a difficulty commonly met with in taper-die operation, especially in the case of dies with considerable taper. The great length of the cores and posts and the excessive compression within the die itself combine to cause this trouble. Sometimes "spreaders"—small screws or pins—are used to overcome this difficulty, but these must not be placed too close to the front of the die or they will develop cracks in the ware. When cores are forced even a sixteenth of an inch out of place, the loss of ware in the dryer may be great.

Whenever possible, it is advisable to avoid the long-mouth die, as the short die is less liable to cause trouble, is lighter to handle, and consumes far less power.

The tile maker should persist in trying to improve upon the type of die he is using until the correct model has been found. Lack of initiative in this direction is responsible for much of the tile makers' troubles.

Effect of Raw Materials.

The clay or shale which is used naturally has considerable bearing on the type of die to be employed, as well as on its construction and methods of adjustment. Some materials slip thru a die like so much grease; others offer a very strong resistance. Some materials can be run thru a die in a very soft condition, while others have to be very stiff. It is these conditions that make possible a wide variation in die construction.

Where an easy running clay is used, the dies can be built very light, the bridge and posts being reduced to a minimum. But where a hard running clay is used, or where it is necessary to run it very stiff, the bridges must be heavy and strong. Light die construction usually produces fast dies, while heavy construction tends to produce slow ones. As a general rule, a die with considerable metal behind it will likely require more adjusting than one with less. This is true because each ounce of metal added to the back of a die offers resistance to the clay flow—in fewer words, acts as a baffle. For this reason, the raw materials available should be studied closely, so that the lightest possible construction may be used in the die and behind it.

It is acknowledged that weathered materials slip thru a die easier than unweathered materials. Most clay and shale banks have a covering of weathered materials. Consequently, if the maximum percentage of weathered material available is mixed with every load that goes to the pans, the best results are generally obtained. When enough of this material is not available, a portion of the unweathered material should be weathered whenever possible. Many clayworkers would be surprised at the good results obtained from the use of even slightly weathered material, in the way of increased speed, reduced-power consumption, and of less die wear, as compared with results obtained with unweathered material.

Fineness of grain (or fine grinding) has more effect on tile dies than most clayworkers realize. Coarse materials invariably slow up a die, and, in general, make the column "drag" at the corners. In some recorded instances, new screen plates in the pans, and new screens ahead of the pug-mill, have speeded up a whole set of dies from 8 to 10 ft. per minute, and at the same time eliminated the "drag" corners. Whenever a die slows down for no apparent reason, look at the plates in the pans and see whether the screen tender is attending to his business.

In addition, the drying qualities of the raw material have a considerable bearing upon the die and its proper adjustment. Some clays go thru a dryer without loss, even when run on a decidedly unbalanced die, while others require perfectly adjusted dies. Cases are known where it seemed practically impossible to run ware on certain dies without excessive, or even prohibitive, dryer loss, and where it was found that various substances could be added to the clay that would make it work with the same dies, and without a marked dryer loss.

The most common of these substances is grog,—pulverized burned ware,—ground in the pans with the clay or shale. Other substances successfully used are tannic acid in crystalline form, common salt, raw limestone, and slaked lime. Sometimes less than 1% of these substances will overcome very bad cases. The raw limestone and salt have proved especially successful.

Even with clays that dry easily and with dies that are perfectly balanced, heavy losses may occur if the ware is "rushed" thru the dryers. Some materials will not stand a progressive tunnel dryer treatment, but, fortunately, there are many that do not require the slower hot floor or open room treatment. Experience, patience, and a great fund of common sense are the only true guides. A. F. Greaves-Walker, in his "Clay Plant Construction and Operation" (pub. by Brick and Clay Record: see pp. 25-26), states that, in his opinion, any material from which other structural products are made can be successfully used in the manufacture of hollow ware, and gives a few examples of what can be done with so-called "impossible" materials; but, he continues, it pays to accumulate all available information, first, and then proceed slowly and carefully in evolving a die that is suitable for the materials to be worked. Radical changes nearly always mean starting all over again.

Factors Important to Dies.

Probably less is known about scientific auger construction than about any other subject connected with the hollow ware or brick industry. One thing, however, is conceded: the design of an auger for hollow ware should be different from that of an auger used in the manufacture of brick. In the former, the diameter remains constant, with the pitch sometimes constant, but generally increasing; in the latter, the diameter decreases with the pitch constant, or increases only enough to maintain the area between the flights constant.

All three types of augers, single-, double- and triple-wing are used. The single-wing is the fastest, but usually the die must be placed so far from the auger (in order to overcome the unequal flow and the lamination) that this advantage is lost. The single-wing auger also has a tendency to make dies flow fast in the center and to cause lamination. This may necessitate heavy baffling at that point, which reacts against speed. As a general rule, the inexperienced clayworker will avoid single-wing augers because (1) equal pressure over the die face is hardest to obtain with this type, and (2) warped ware—particularly with thin shapes—often results from its use.

The double-wing auger is commonly used and gives good results. Theoretically, the triple-wing should be preferable and give a minimum amount of die trouble, since it provides more even pressure on the column. Three wings, however, displace considerable clay in the machine barrel, which may be a serious matter where large tile are to be made. Also, more friction is set up in the barrel, and, where hard-running clays are encountered, this may seriously interfere with column speed.

In some cases, the auger is run thru the barrel as a continuous screw, either single part of the way and double the balance, or double all the way; in the case of a triple-wing it may begin as a single under the hopper, then change to a double, and finally to a triple-wing at the tip. In other cases, the screw is broken in the sections back of the tip or ordinary knives are used, as in a brick machine. Materials vary so much that only by experimenting in each case can the best type be determined, as results vary greatly in every case.

A common annoyance in tile manufacture is due to wear of the auger. A die may run perfectly and at a satisfactory speed with a new auger which has been run just long enough to get a polish, but this same die may grow troublesome as quickly as the auger begins to wear at the circumference and a space is opened up between it and the barrel. This space around the auger offers a point of release and allows the clay to slip back; that is, it allows the pressure to be released at the outside corners and walls of the die, while the center keeps up its speed.

The result is an unbalanced die and the necessity for baffles in the center; but just as soon as a new auger is put on, the center is slow and the baffles must be removed or smaller ones substituted. Taking care of auger wear is a serious problem.

Alloy Steel Augers.

Some authorities are advocating wide experimentation with augers of alloy steels, such as manganese, chrome, nickel or vanadium, especially among the larger manufacturers. Such dies, however, should be polished before being put on the machine. Otherwise, the loss in production makes their use almost prohibitive, as it is estimated that a certain die which will run 12,000 ft. of ware per day under good conditions, will, if put on the machine unpolished, run about 5,000 ft. the first day, perhaps 7,000 ft. the second, and about 10,000 the third, and on the fourth day will be up to capacity. The loss—say, 10,000 ft. of ware—must be charged to "polishing" the die. Reduced to dollars, perhaps half this loss would install a portable grinding and buffing wheel with a flexible shaft, and for $5 additional for labor, every auger could be ground and buffed until it became mirror-smooth.

The use of an auger with a lip is also recommended, since the lip adds life to the auger by keeping the edge from wearing away as rapidly as is common.

Worn barrel liners also have the same effect upon the die as a worn auger and tend seriously to decrease the life of the auger by allowing the clay to slip back around it. One-half inch is considered the maximum space that should be allowed around an auger, and this is often too much.

Distance of Auger from Die.

Hollow ware machines are supplied with extension rings to permit the die to be placed at its proper working distance from the auger. Tile of no great variation in size can generally be run at the same distance, once the proper distance is determined; but where there is a great difference in size the distance will change with the majority of raw materials, and cannot be specified under any circumstances, as it is absolutely a matter of experiment. The type of machine, speed of machine, raw material and dies are all determining factors. For this reason a die which fails when placed five ins. from the auger tip may run splendidly at ten ins. Each fractional increase in the distance of the auger increases the power consumption, however, and it is thus necessary to keep the die as close as possible and still get good results.

The warping or cracking, often caused by having the die too close to the auger, is due to the weave given the column by the auger; when the die is very close, the weave may be noticed as the column runs out; at other times it does not show up until the ware is dry.

Very important in some cases where large tile are made is the space between the die and auger which acts as a reservoir from which the clay is evenly forced thru the die by the "push" of the auger behind it. Unless this reservoir is large enough, or, rather, unless the bulk of clay between die and auger is great enough, the auger action or pressure is liable to be localized, the tendency being towards fast flow in the center and slower flow at the outside. Baffling the center of the die (which naturally will slow the column and cut capacity), or increasing the distance of die from auger without a reduction in speed, are the common remedies.

Best practice also requires the barrel of the machine to be proportionate to the size of ware produced. For such tile as 4-in. by 12-in., 3-in. by 12-in. and 5-in. by 8-in. column, covering Denison tile, etc., the barrel should be 16 to 17 ins. in diameter. For the larger tile, the barrel should be only slightly larger than is required for the largest size.

When a large barreled machine is used for small tile, the clay itself forms a tapering nozzle between the auger and the die, causing an excessive compression of the clay and a reduction of the possible column speed.

Force-Feed.

A force-feed apparatus of some sort is now considered a necessity. The market offers a number of these, and most of them have merit. Naturally, where a pug-mill is combined with the machine it acts as a force-feed apparatus. Some raw materials require a mechanical force-feed to assist the auger to keep up the required pressure behind the die, as no amount of punching by a "human force-feed" will prevent the uneven pressure from causing much loss at the dryer. Even where a mechanical force-feed is used, care must be taken to make the pug-mill keep the hopper full or the same "mysterious" dryer losses will occur.

Metal on Back of Dies.

In the foregoing paragraphs have been considered those factors outside of the dies which have an effect on die construction and adjustment, since it is almost a hopeless proposition to consider the dies themselves unless some knowledge of these outside factors is possessed.

In reference to the dies themselves an important factor is the distribution of metal at the back of the die, in the shape of bridges, cores, bridge-posts, nuts, studs, etc. Obviously, even a single thin bridge placed back of the die opening will tend to interfere with the equal flow of clay and also with the speed of that flow. The object, therefore, of the die builder should be to reduce this interference to a minimum by making bridges, posts, cores, etc., as light as the service required of them will stand, and also to distribute these metal parts over the back of the die as evenly as possible, thus "balancing the interference" and causing the clay to flow evenly. If this is not done and the bridges (for example) are concentrated over any particular part of the die, the resulting interference with clay flow at that point will produce a slow area. This will probably have to be counterbalanced by baffles over the fast areas, with consequent reduction in column speed. A close study of dies in action, together with a little experimenting, will enable the clayworker to overcome many die troubles by a slight shifting of the bridges and posts.

Whenever possible, baffling a die with metal plates should be avoided; other methods usually entail more work to get a balanced die, but this is offset by increased tonnage, and reduced power consumption.

When a new die is put on the machine, the bridges, cores, etc., must get a polish before anything definite can be told as to the final results it will give. In such cases it is wise to use baffles where necessary, since, after a short time, the die may run well enough without the baffles. If it doesn't the faults should be corrected.

If, for instance, the middle cross-webs or web is very much faster than the balance of the die, a shim consisting of a thin piece of steel can be fastened to the cores, thus making the webs slightly thinner. Sometimes 1/32-in. will suffice; and as it is seldom that even one-eighth-in. in web thickness will affect the safety or sale of a tile, this amount cannot ordinarily be objectionable.

On the other hand, if the webs cannot be made thinner (because of reducing the safety factor), a thin cut in the sides of the cores next to the slow walls or webs, thus slightly increasing the size of these walls or webs, will have the same effect by speeding up the slow portions of the die. When only a single web or wall is slow, it is easy and effective to open the die at this point, and much better practice than baffling the entire die down to the speed of this slow portion.

Sometimes a tile is so shaped that one or more of its webs are much thicker than all the others; a die of this shape obviously is difficult to handle. A method of balancing, however, shown in Fig. No. 1, has been found successful in some extremely troublesome cases, in which it has eliminated the use of baffles and increased the column speed up to five ft. faster per minute.

Scorers and Scratchers.

The type of scorer or scratcher used has a very considerable effect on the die. Whatever the design of the scorers, their shape has a tendency to drag at the walls of the tile, invariably slowing them. As the grooving is absolutely necessary, the speed of the whole die must be made to conform to the grooved walls. The number of grooves makes a difference, however, and this may be taken advantage of in adjusting the die. For example, if a die has a slow wall on which are six grooves, a reduction to four or five may correct the trouble. When flat steel scorers are fastened on the outside of the die they can be moved in or out to make more or less resistance.

Metal Baffles.

When necessary, the metal plate may be used to prevent local fast areas in the die, the plate being fastened to the die plate or bridge, according to the location of the trouble. The method of adjustment is simple, but may lead to increased power consumption, slow running columns, smashed bridges, or even smashed dies. Sometimes a die is so constructed that a thin core is so exposed to the clay pressure that it shifts, thus unbalancing the die; in this event, a small baffle may be placed on top of the bridge in such a position that some of the pressure is taken off the exposed side of the core, allowing it to retain its normal position. Care should be taken to make a baffle as small as possible and still get desired results.

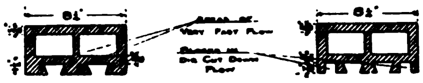


Fig. 1. On Left, Original Shape of Jamb Tile Die Decidedly Unbalanced. On Right, New Shape of Jamb Tile Die Perfectly Balanced.

Bridge Cracks.

When a bridge crack occurs, this clearly shows that the clay has not had sufficient opportunity to knit from the time it passed the bridge until it issues from the die; or, putting it the other way, the bridge is too close to the point of issue. To overcome the difficulty, it may be necessary to set the bridge back from one-half in. to three or four ins.

Materials vary so greatly in their knitting or "welding" qualities that the proper distance can be determined only by experiment. Moving the bridges back a little at a time will stop the trouble when the proper distance has been reached. As a general rule, once the proper distance is found, all bridges can safely be placed at that distance, but occasionally some one die will require a special treatment.

Various means are used to assist the clay in knitting. One of these is to serrate or "saw-tooth" the bottom of the bridges; another is to wrap a chain around the troublesome bridge. In the latter case, it is best to move the bridge back slightly, as the chain has to be constantly replaced. The temper of the clay may also have a bearing on bridge cracking, since some material will knit readily when given a certain temper and refuse to knit when the clay is not so treated.

Die Wear.

Just when a die is worn out and ready for the scrapheap or the machine shop is difficult to decide; but when a die begins to slow up, and cause a loss of from two to ten ft. of ware per minute, this also means that the cost of manufacture is mounting, due to the increased thickness of the walls and webs and to the increased freight bill when the ware is shipped. Thus, a slow die both decreases tonnage and reduces profits on the tonnage produced at the same time; and the manufacturer has only to sit down and figure the approximate cost of these in comparison with the price of a new die to realize the advantages to be gained by discarding the slowed-up die. It is undoubtedly good practice to withdraw from use a worn die; and it is unquestionably bad practice to use a die which has once been thrown away.

There are a number of dies on the market, which, with occasional minor repairs, will last for many years, all wearing surface except the bridges being lined with the same material. In other types, the dies and cores are lined in the same way with mild steel or cast-iron. Generally, the design of most dies can be modified to permit lining and relining, and thus cut out a source of loss. Ordinary cast-iron wearing parts should be generally avoided; better materials, which can be easily machined, are available in all up-to-date foundries, and case-hardening of most of the wearing parts is not a difficult matter. The first cost of a die may be increased perhaps one-third by following these suggestions, but the expenditure will pay dividends in the long run.

Tool Steel Dies.

Altho it has been claimed that tool steel slows up a die, this objection is not generally conceded by die experts, who suggest that further experimentation will prove their claims for this material. (See also Auger, brick and hollow ware, Auger machines.)

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

193—DIE, HOLLOW WARE.—For all practical purposes hollow ware dies may be separated into two distinct types, flat and tapered.

Flat dies are always dry, but the tapered type may be either dry or lubricated with oil, water or steam. Hollow ware dies may have from one to nine cores to make a corresponding number of holes in the finished product. There is practically no difference in the methods of adjusting the two types when run dry; but the complicated construction of the lubricated taper die frequently causes more or less trouble in securing proper adjustment.

In the flat type the openings are almost always straight; that is, the sides of the die plate are parallel thru the entire thickness of the die. In the tapered type the die tapers on all sides down to the face plate; the sides of the die being parallel with the sides of the core only thru the thickness of the face plate.

Hollow ware dies are made from a number of grades of metal, ranging from cast-iron to tool steel.

Hollow Tile and Conduit Dies.

These are operated in conjunction with auger machines, being generally fastened to a bridge or set of bridges placed inside of the machine, a certain distance, so that the cores will be flush with the outside face of the die. The construction of bridges, cores and die must be planned with great accuracy, since small variation from correct practice will result in considerable trouble and consequent loss of production. See also Die, factors of operation.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

195—DIE, MACHINE, BOLT.—This type of die is similar to a pipe threading die. The body consists of a casting or frame in which is held a die equipped with hard steel threads. This die is changeable, one being employed for each size of thread. The threads in the die are arranged so that when the die is revolved by the two bars or handles that are attached to the center casting for that purpose, they cut a standard thread in the bolt or bar which has been placed thru the die.

In many cases the stock, as the center casting and bars, is called will take care of either a machine bolt die or a pipe die. At times a bolt die is placed in a machine lathe and the thread cut on the bolt as the lathe revolves.

DIE, PIPE-THREADING, see Pipe threader.

195A—DIE-PRESSING, DRY AND PLASTIC.—A term that refers, in the pottery industry, to a special process of manufacturing a large variety of articles, especially those used for electrical purposes.

The material used in die-pressing is generally ground to a fine dust and slightly dampened. The molds or dies are of steel, each formed to make the desired article. The die is placed in a screw press or hydraulic press, and the dampened dust is put into the die and squeezed under great pressure. In many cases, the dies are extremely complicated. The dust usually contains about 8 to 10% of water. The method of making from dust is used for such articles as tiles and small pieces, complicated in shape, as for electrical purposes. The articles are fragile, the corners and edges easily breakable. The principal faults are wind-blown ware and cracking.

For plastic die-pressing, instead of the top plunger descending into the bottom die, the outer edge of the top die descends over the outer edge of the bottom die, a cavity being allowed inside which gives the required thickness and shape to the article. The bottom die is fitted with a loose bottom, which can be lifted by means of a lever; after the article is made, this lever is used to lift it from the die. The articles thus made are stiff and can be readily handled. In this case, the clay is first cut to rough shape in the plastic state and then allowed to dry to the required degree of hardness. In plastic pressing, the die is kept well lubricated to prevent sticking, the oil used generally being a mixture of rape-seed oil and petroleum. The principal faults are cracking and warping.

DIESEL OIL ENGINE, see Engine, internal combustion.

195B—DIE, SEWER PIPE.—The dies used in sewer pipe manufacture are similar to drain tile dies, that is the die proper is circular and made to form the outside of the pipe. When each piece of pipe is started out of the die a casting for forming the socket is clamped onto the outside of the die by means of hooks. When the socket has been formed the casting for that purpose is unfastened from the die and the pressing of the pipe is then completed.

The core of a sewer pipe die consists of a large casting beveled on the inside and fastened to a bridge in a solid, immovable manner. The width and bevel of sewer pipe dies are very important, as the quality of the ware is dependent to a great extent on the proportionate construction of these parts.

MANUFACTURERS (see catalog section):
Stevenson Co.
Toronto Foundry & Machine Co.

196—DIGGING MACHINERY.—There are several types of machinery in use today, built especially for digging clay, in addition to the usual types of steam shovels and other machines that are suited to any kind of excavation. The main object in addition to economy of operation is to intimately mix the entire deposit of clay uniformly. When the upper and lower strata differ in essential qualities this is a big advantage. One form of machine consists of a wheel about 12 or 15 feet in diameter which revolves against the bank of clay, cutting thin slices by means of cutters which are mounted on the periphery of the wheel. This material is loaded into cars automatically. Another type consists of a small machine like a steam shovel. The boom is raised and lowered and the bucket either pushed or pulled into the material to be loaded. These machines are especially suited to plants using a small tonnage as the cost of operation is not as large as a regular steam shovel, in fact is in line with the tonnage of the output. The cost of digging and the uniformity of the clay or shale show a large benefit over the process of hand digging. (See also Shovel, electric, power and steam; Excavator, drag-line; Planer, shale; Ditching machine.)

MANUFACTURERS (see catalog section):
Eagle Iron Works.
Steele, J. C. & Sons.

197—DINKY.—A term used to denote a locomotive used in pit or factory, and fully described under the several items given to locomotives.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

DIPPER'S MANGLE, see Mangle, dipper's.

198—DIPPER TEETH.—Dipper teeth are the projections which are fastened to a power shovel bucket and which do practically all of the digging. On account of the extremely hard service which they have to withstand, every possible method has been used to keep them in as good cutting condition as possible, and thereby avoid the lost time and expense of replacing or sharpening. The best practice is to have two sets of dipper teeth so that one set can be sharpened while the other is in use. The time of changing in that case is limited to the time necessary to remove and put in the rivets which fasten the teeth to the bucket. The teeth should be sharpened by a man experienced in that work because if they are too hard they may break and if too soft they will wear out quicker than they should. Steel and manganese steel are the metals of which most teeth are made. Some teeth are made in two parts, the main piece staying on the bucket and the smaller piece, which includes the point, being fastened thereto. These are easier to change and easier to sharpen. In some cases these smaller removable pieces are made reversible, so that one sharpening will serve for two periods of work. (See also Shovel, electric power and steam.)

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

199—DIPPING.—A potter's trade term to indicate the immersion of clay ware, ordinarily in the biscuit state, in a vessel containing the slip in such a manner that the ware is completely and uniformly coated. The correct proportions of solid matter and water are of the utmost importance in this operation, and can be generally obtained only by making slips of varied strengths and sending the trial articles dipped in the slip thru the kilns. The strength of the slip is conveniently expressed in "ounces per pint," and when the correct weight has been ascertained for any particular slip it is henceforth simply a matter of maintaining it at that standard. The personal equation is an important factor, however, as different workmen require a slightly different density of slip.

DISC FEEDER, see Feeders and mixers, clay.

200—DISINTEGRATOR. — Used for breaking up clay or shale. They consist of several drums, or knives on axles, revolving rapidly within a case and in opposite directions. As the lumps of clay are dropped into the machine they are thrown violently about between the drums and also strike against each other, thus pulverizing the material completely and rapidly. Their capacity is large, but much power is also required to drive them. They will handle either wet or dry clay, and are usually mounted so that the cars or conveyor belt will feed directly into them. When possible the disintegrator is located so that the clay will drop into the pug-mill or the finishing machine, whichever is used. One type resembles a roll crusher except that only one roll is smooth, the other having knives, bars or corrugations by which to break up the clay. Another type resembles a pug-mill but the barrel is wider at the top and the whole construction is planned to feed the clay thru without packing as it does in a pug-mill.

The capacities of disintegrators vary from 60 to 400 tons of clay per day and require from 10 to 40 h. p. to operate. They are used to reduce clay to lumps no smaller than one-half in. in diameter.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Wellington Machine Co.
Williams Patent Crusher & Pulverizer Co.

201—DITCHING MACHINE. — Ditching machines are constructed with an endless chain of cutting knives and buckets, or a large wheel with similar attachments. They are very desirable for digging drains or ditches of any kind, and the size of width and depth of cut can be made comparatively large. Most of the work can be found around open pit work or for constructing farm drainage systems or sewers.

202—DOLOMITE AND MAGNESITE.—Dolomite ($CaMgCO_3 = CaO$ 30.4%, MgO 21.7%, CO_2 47.8%) and magnesite ($MgCO_3 = MgO$ 47.6%, CO_2 52.4%) are minerals resembling calcite. Both may occur in clay, and either is highly refractory, but when present with some other minerals exerts a fluxing action, tho not at a temperature as low as lime.

The grains of dolomite in some residual clays derived from dolomitic limestone may be clearly visible in those parts of the clay which have not been highly disintegrated.

Dolomite and magnesite are used most profitably in basic Bessemer, open-hearth, and other furnaces for the manufacture of steel and other metals, where high temperatures are required in the presence of basic slags. They withstand these slags at high temperatures better than any other material. Dolomite is cheaper than magnesite but is much harder to make into brick. Either material is used as calcined powder mixed with tar or other non-injurious binder, for a mortar to lay up magnesite brick or as a hearth or floor of the furnace for melting the metal. Magnesite is made into brick by several methods, but in general the brick consist of a mixture of dead-burned and caustic magnesite. The former is magnesite that has been burned to such a high heat, about 1,850 deg. C. (3,362 deg. F.) that it will not slake in the atmosphere. The latter is magnesite that has been calcined to a temperature of about 800 deg. C. (1,472 deg. F.), and which will slake the same as quicklime in the atmosphere. The mixture is pressed in a dry press or other machine of equal pressure, and burned to a temperature of about 1,710 deg. C. (3,110 deg. F.). The bond is very weak so that the brick cannot be set more than two or three high. About half of the kiln, therefore, is taken up with silica brick which is set so as to form boxes and carry the weight of the magnesite. The magnesite brick are set into these boxes not more than two or three high.

203—DRAFT GAGE AND METER.—Instruments for determining the amount of draft in a kiln or boiler. Draft is caused by the increased velocity or pressure of the flue gases over that of ordinary atmosphere. A draft gage works on this principle, as one end of a glass tube containing a liquid is open to the atmosphere and the other is connected by a rubber tube or a pipe to the stack or flue whose draft is to be ascertained. The passage of the flue gases creates a partial vacuum in the one end of the tube and the atmospheric pressure exerted on the other end causes a lowering of the level of the liquid in the tube. A scale is provided, by which the height of the liquid indicates the amount of draft in the kiln or boiler. Economical fuel consumption requires a definite amount of air and this is obtained only when the proper draft exists. A draft gage assists in determining whether or not the proper draft does exist, and therefore whether or not full economy is being obtained. (See also Anemometers; Air flow meter; Pitot tube, and Manometer.)

MANUFACTURER (see catalog section):
Brown Instrument Co.

DRAG SCRAPER, POWER, see Excavator, drag-line.

204—DRAIN TILE.—This class covers (1) tile, of horseshoe-shaped cross section, (2) sole tile, cylindrical with a flat base, and (3) pipe tile, with cylindrical cross section. For manufacturing drain tile, the clay is thoroly tempered before molding, usually in a pug-mill; the molding is usually done in some form of stiff-mud machine, the cylinder as it issues from the die being cut into the desired lengths; and the drying is commonly done on pallet-racks, such as are used for common brick, altho it may be done in tunnels. The burning, commonly at a low temperature, is done in a variety of kilns, the tile at times being burned with common brick. They are used for any drainage work, and especially for drainage of farm land.

Hot floors are also used extensively for drying drain tile. See also Dryer, floor.

205—DREDGE.—A dredge is a machine for digging a wide open ditch or trench. It is usually built very much like a large steam shovel and part or all is made to revolve so that the earth can be dumped on the side.

DRESSING, BELT, see Belt dressing.

DRESSING, WIRE ROPE, see Wire rope compounds.

208—DRILL, DIAMOND.—This is the most important tool used in testing clay deposits that bores into the materials by means of rotation. The working part of the drill is the crown, a short piece of tool made of cast-steel at one end of which is set a number of black diamonds which fit into small cavities made for that purpose. The crown is screwed onto wrought iron pipe that constitutes the boring rod. This is made to rotate and, as a result, a groove is cut at the bottom of the hole leaving a core which can be brought out with the rod.

Strata of stone, coal and any changes in the clay or shale are shown exactly as they occur, and the cores, when preserved, give an exact record of the various occurrences and enable the clayworker to prepare for contingencies long before they have to be met. Diamond drilling, as a rule, is done by companies organized for that purpose, since the operation requires the services of experienced or expert help.

209—DRILL, ELECTRIC PORTABLE.—Many times drilling work is necessary in the plant and it is impractical and often impossible to remove it to the machine shop for the drill press. In these cases a portable electric drill is indispensable. A regular twist drill is used and it is driven by the shaft of the motor thru a flexible coupling. An operator holds the drill against the work. For this reason the work is somewhat restricted and slower than on a drill press. A frame can be rigged up to replace the operator in taking the thrust of the drill, and when this is done its effectiveness is enlarged. This machine can also be used for boring holes in wood.

210—DRILL, HAND-AUGER.—The hand-auger drill provides the simplest means for testing the nature of a clay deposit. It consists merely of a carpenter's wood auger of not too great a pitch, about 1-ft. long and 1½ and 1¾ ins. in diameter. To this is welded a ½-in. steel rod about five ft. long, the upper end of which is threaded with a pipe thread. A handle is provided to obtain an easy working leverage. A sufficient number of sections of ½-in. pipe are provided to lengthen out the drill as it goes down; the sections are about four ft. long each. Each time the drill is run down a few inches it is pulled up, and the borings that come with it are examined and preserved for future tests. A simple three-leg set-up over the hole with a block and tackle at the top may be used to lift the auger out of the hole after it has been sunk to considerable depth. This auger is used also in many cases for drilling clay before blasting, during the regular operation of a mine or pit. (See also, Blasting tools.)

210A—DRILLING MACHINERY.—In some cases shales, and fire clays, and many surface clays, must be loosened by explosives before they can be worked. Some use the old hand bar for drilling the holes when the amount of work to be done or the extreme inaccessibility of the clay makes a machine impracticable. In the majority of cases, however, especially in the larger plants, a drilling machine effects a great saving in labor.

The drilling machinery may be a regular steam drill, one of the well drilling type, which is mounted on a wagon frame for easy portability, or it may be of the type of pneumatic hammers or again may be a reciprocating bar driven by an electric motor.

210B—DRILL PRESS.—A drill press is a machine for drilling holes in metal. The metal is fastened to a bed which can be raised and lowered or turned sideways on an upright spindle. It can be locked in any position. The drill is mounted on an upright shaft which is revolving constantly, and is fed into the work either automatically or by means of a lever or wheel in the hand of the operator. The speed of the revolution of the drill and also its feed can be adjusted. Twist drills are almost universally used. This machine can also be used to ream out holes that have been cored in a casting, by substituting a reamer for the drill. It can also be used for countersinking a hole.

211—DRIVE, BELT.—These are used to transmit power from one line shaft to another. The belt is pulled around by the rotation of the driving pulley and it in turn pulls around the driven pulley. The belts are made of several kinds of material. (See also Belting, fabric; Belting, leather; Belting, rubber and composition.)

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Freese, E. M. & Co.
Gandy Belting Co.
Goodyear Tire & Rubber Co.
Link-Belt Company.
U. S. Rubber Co.
Weller Manufacturing Co.

212—DRIVE, ROPE.—A rope drive is the system or arrangement by which power is transferred from the engine, motor or other source of power to the line shaft, or machine that is to be driven, by means of rope. The "rope" is a wire cable, or manila rope. The pulleys used on the line shaft, when a belt drive is used are replaced by a series of sheaves over which the endless rope runs. The number of sheaves at one point for a rope drive depends entirely on the amount of power to be transferred, and is unlimited. No slippage or lost motion, and less time required to make repairs, are two of the most important arguments in favor of this system of drive.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Link-Belt Company.
Weller Manufacturing Co.

213—DRIVE, SILENT-CHAIN.—The method of transmitting power by means of a silent-chain belt running over sprocket wheels made to fit the belt. See also Belts, silent-chain.

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Link-Belt Company.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:

Link-Belt Company, Philadelphia, Chicago, Indianapolis. Other offices in principal cities. Over 50 clay plants have adopted Link-Belt Silent Chain as the standard drive to operate fans, line shafts, pans, pug-mills, washers, agitators, glaze mills, etc. It transmits the power of the motor without slip, and is 98.2% efficient on actual test. *It is flexible as a belt—positive as a gear—more efficient than either.* The use of the Link-Belt silent chain drive simplifies the power transmission problem. Silent chain operates on short centers and can therefore be encased in an oil-retaining dust-proof casing, requiring a minimum of attention for lubrication and care. The result is a smooth, quiet drive, having decided advantages over the older forms of power transmissions. Our experienced engineers can help you get better results from your power transmission equipment. Their advice is yours for the asking. Send for our specialist on clay working machinery drives. Also send for a copy of our book No. 310.

214—DRUM, WINDING.—A winding drum consists of a hollow wood or metal cylinder, mounted on a revolving shaft, and deriving its power from a separate shaft, by the use of suitable gear reductions or friction rollers. The types and sizes of winding drums vary greatly. Ordinarily, the drum and accessory equipment are self-contained and mounted on a substantial cast-iron base. Two levers control the operation. One is used to start or stop the drum at will; the other controls the friction band brakes which are used to regulate the speed of hoisting or lowering the load. In the clay products field, winding drums are extensively employed, not only for all kinds of hoisting and elevating work, but for hauling, by the use of wire cable, the loaded dump cars from the clay pit to the machine.

MANUFACTURERS (see catalog section):
Bonnot Co.
Freese, E. M. & Co.
Green, L. P.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

DRYER CAR, see Car, dryer.

216—DRYER CONSTRUCTION.—We have tried in preparing this chapter to avoid theoretical calculations which mean little, if anything, to the average clayworker, and to present instead such helpful suggestions as will enable the dryer builder to avoid some of the after-annoyances to which so many dryers are heir. No clay plant owner, however, should attempt dryer construction without first having consulted with the manufacturers of the different types of dryers, and also with an expert not prejudiced in favor of or against any particular type, or any particular dryer. In importance only one other part of a clay plant, namely, the kiln, requires the care and thought in its design that the dryer requires, since it is practically impossible to pick out, promiscuously, one of the many types of dryers available without inviting future losses which at times become appalling.

Every Type Different.

A certain type of dryer may work splendidly on stiff-mud brick made of easy drying clay, but will fail utterly on the same brick made of tender clay. Again, a dryer may work excellently on stiff-mud brick, but will not dry successfully soft-mud brick made from the same material. One tunnel-type dryer may handle hollowware successfully on the continuous principle, while another tunnel dryer would have to be operated on the intermittent plan, in order to safely dry the same ware from the same clay. Thus, many clayworkers are learning that, while they have for years been duplicating drying units, which appeared to them to be the best adapted to their particular case, they could have installed other systems which would have saved large amounts of money thru greater speed with smaller losses of ware. Most open-air dryers are to be found on plants using the soft-mud process which are operated only during summer months, the drying being generally done in racks, the pallets being wheeled out on trucks and later again moved by trucks from the racks to the kilns. The cost of drying under these conditions is higher than in most artificial dryers, largely because of the several handlings necessary between the ware-producing machine and kilns. On large plants, the drying racks cover a large area and the distances covered by the truckers is considerable. In some cases, the investment in racks amounts to a large sum and their exposure to the elements causes excessive depreciation.

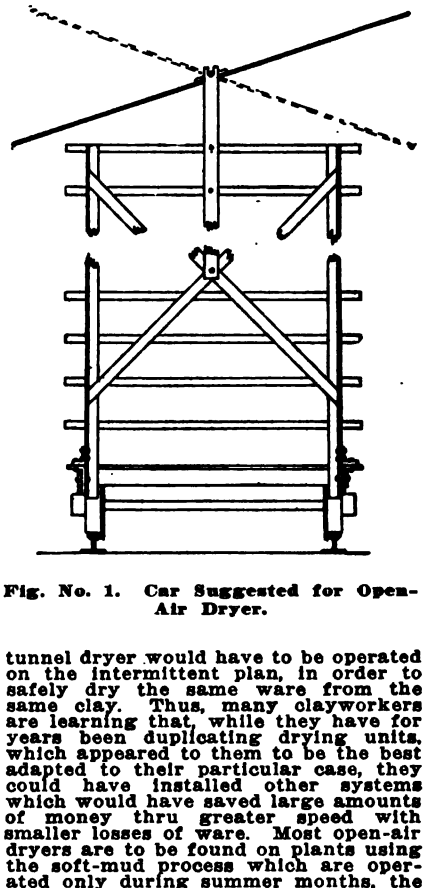


Fig. No. 1. Car Suggested for Open-Air Dryer.

Good Open Air Dryer.

Many clayworkers have sought for a means to eliminate some of these bad features without erecting dryer buildings, and, to overcome some of the difficulties encountered with the racks, the following method is suggested

Any number of tracks of length convenient to the layout of the plant are laid down in the open. Regular cars of soft-mud, stiff-mud or hollowware—are provided, of the same type and gage as used in artificial dryers. Each car has a removable sheet-metal roof, which can be tilted to protect ware from rain and sun (see first illustration). By this system the ware is placed on cars at the machine and not handled again until it is run into the kiln. There is likewise the advantage of having both cars and rails ready for immediate use, if an artificial dryer is planned for the future. The upkeep of the cars is appreciably less than that of wooden racks, and the system eliminates a bad fire risk, which is ordinarily non-insurable.

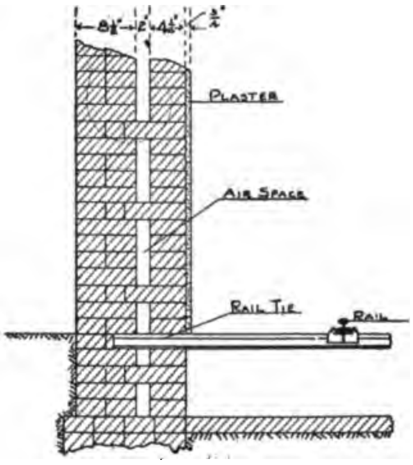


Fig. No. 2. Section of Dryer Wall Showing Air Space.

Artificial Dryers.

The difference in first cost favors the racks slightly, but not much. The method is very useful on hollowware plants making large shapes which are difficult to dry safely in an artificial dryer; it can thus be used in summer months to make a stock of troublesome shapes which can be carried over thru the winter. If necessary, a low wooden framework can be built on the outside of the two outer tracks, from the top of which rolls of canvas can be dropped to protect the outside cars from driving rains. The cars on the inside tracks are so close together that there is no danger to the weather from this source. The main or primary object of all artificial dryers is to remove the moisture from the ware with the greatest possible speed at the lowest cost, at the same time taking into consideration the safety of the ware. To obtain these results three important factors must be considered: (1) the velocity of the gases thru the dryer, (2) relative humidity of the gases, (3) the temperatures of the gases at the various points. The materials most commonly used for dryer-building roofs are lumber, brick and cement; strangely, hollow tile has found favor with but few constructors. Primarily, of course, the shell of the building is put up to prevent the escape of heat to the atmosphere until the heat has done its work. In fact, it is the earnest desire of the clayworker to prevent heat loss either directly or by radiation. Yet in about 99 per cent of dryer buildings no real effort is made to prevent radiation, altho at ordinary drying temperatures insulation of walls and roof is an easy matter, and can be accomplished without extra cost.

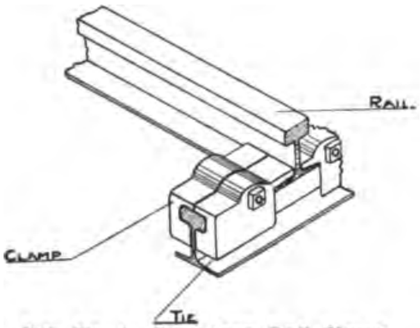


Fig. No. 4. Cast Iron Rail Clamp.

Brick Walls with Air Space.

Lumber for dryer buildings is condemned for many reasons; first, because of the fire risk; second, because frame buildings of this type soon become as open as a sieve. Even when care is taken to insulate the walls the effort is generally a failure, due to the green lumber used and the drying temperatures within being high. Brick is an excellent material for dryer-wall construction, provided the walls are built with an air space. Usually it is best to build the walls 1½ bricks thick (see second illustration). It will be noted that the air space is broken up by header courses. This plan breaks up air currents which otherwise would be set up and have free flow from bottom to top of walls. The coat of plaster on the inside of the outside walls has been found to give such good results that its general adoption is only a matter of time. By actual test, a wall plastered on both sides will radiate 20 per cent less heat, and a wall plastered on one side will radiate 10 per cent less heat, than an unplastered wall. (This should be noted by clayworkers troubled with cold outside tunnels.) The plaster will adhere to the wall, if brick having a good suction are used inside and the mortar joints are raked out to allow the plaster to key into them.

Concrete Dryer Walls Fail.

Concrete dryer walls are a generally accepted failure. They hold up the roof and prevent all heat from getting away, but they are themselves poor insulators. In comparing fuel consumption of outside tunnels of two radiation dryers, one having 12-in. walls of brick, the other, 12-in. walls of concrete, the fuel consumption of the concrete dryer was 30 per cent higher than that of the brick dryer. Both dryers were identical except for material in the walls and both were drying the same ware. Building thin concrete walls with an air space might overcome the difficulty, but while these are possible, they are not practical.

Hollow-Tile Ideal Material.

Hollow-tile is ideal material for dryer walls; it has the necessary strength, the cells provide necessary air spaces, and the tile are usually scored for plaster. No. 1 tile is not essential for this type of building; good seconds make an excellent job. A tile dryer-wall should be 12 ins. thick and should be plastered to obtain best results.

Waterproofing Dryer Walls.

Where dryer walls (not footings) extend below grade in order to protect flues, as in radiation dryers and some waste-heat and steam dryers, they must be waterproof. Due to rapid evaporation on inside of such walls, the amount of moisture drawn thru them is very great, and this is usually made worse by the fact that eaves-troughs are seldom provided for dryer buildings. The effect of moisture, combined with the radiation from outside walls, often decreases the efficiency of outside tunnels 50 per cent.

The walls below grade should be plastered on outside with a mixture consisting of two parts sand and one of cement, which, after setting, should be given a good coat of tar. This waterproofing below grade is as important as insulation above grade.

Drainage.

In general waste-heat and radiation dryers are the types that suffer most from lack of drainage. Waste-heat flues and the under flues of the dryer buildings are, more often than not, saturated with moisture during and after a wet spell. In some plants, a waste-heat flue is deliberately used as a drain for the surface water of a yard; in other words, the clayworker actually puts moisture from outside sources into a building which is designed to extract and conduct away moisture from the ware put into it.

Waste-heat flues should be drained by running drains under them and by draining surface water away from them.

The under-flue system of a dryer, whatever the type, should be underlaid with a series of drains that will carry away every particle of moisture possible.

Unless the dryer is properly drained, it is impossible to get dry ware during a wet spell, regardless of how much fuel is used in the auxiliary heater. Moisture in the flue system is the key to the dryer-fuel expense in spring, fall and winter.

Construction of Dryer Roof.

It is folly to expect a reinforced concrete or steel and brick roof from 3 to 4 ins. thick to prevent excessive radiation and keep out moisture. Any clayworker who has put a second story over his drying tunnels and used it for drying purposes, knows that he can dry in the upper story about as well as in the tunnels simply from radiation thru the dryer roof. Furthermore, the type of roof mentioned should be protected from rain and snow by a protecting roof, otherwise a large percentage of moisture from this source will find its way into the tunnels. If it is proposed in the future, to put a second story over the tunnels, to increase the drying capacity, as is often done in hollowware plants, a thin solid roof over the tunnels is the proper construction; otherwise, every effort should be made to construct a roof that will prevent practically all radiation.

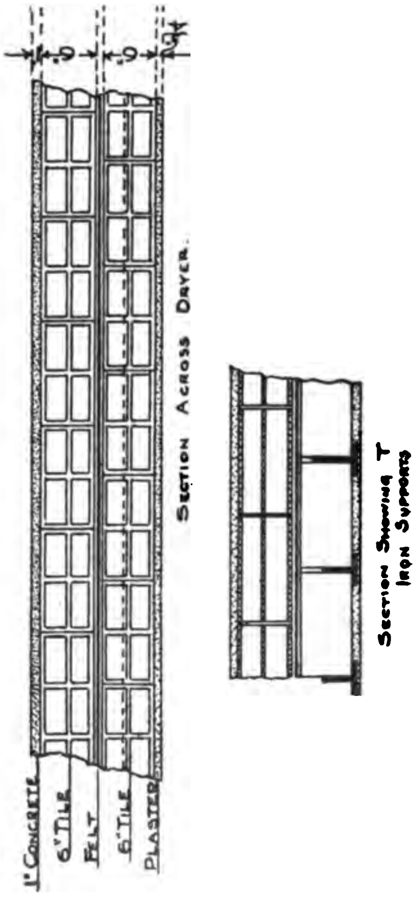


Fig. No. 3. Dryer Roof Design.

In the third illustration is presented such a dryer-roof design. It consists of two courses of four-cell, 6-in. hollow tile with a layer of insulating felt between. The under side is given a coat of ¾-in. cement stucco, mixed very lean, and the top is coated with 1 in. of cinder cement. The tile are supported on "T" irons spaced on 1-ft. centers. This efficiency of this roof in preventing radiation will soon pay any additional cost. While a roof of 4-in. partitions or book tile is fairly good, it is too thin to be really efficient.

The most modern method of overcoming track difficulties in hot tunnels is to avoid wooden ties and use steel rails for ties (see fourth illustration).

The rails are built into the dryer walls and are therefore stationary. The tracks are laid on these steel-rail ties and fastened to them with cast-iron rail clamps, as illustrated.

Wooden ties are objectionable for several reasons; they will not hold spikes for any length of time; the combined moisture and heat tends to shrink and rot them; and, in some dryers there is constant danger of wood ties catching fire.

The rails in dryers are also often too light for the work; 20 to 25-lb. rails do much to eliminate trouble, as they do not kink under the weight they have to carry.

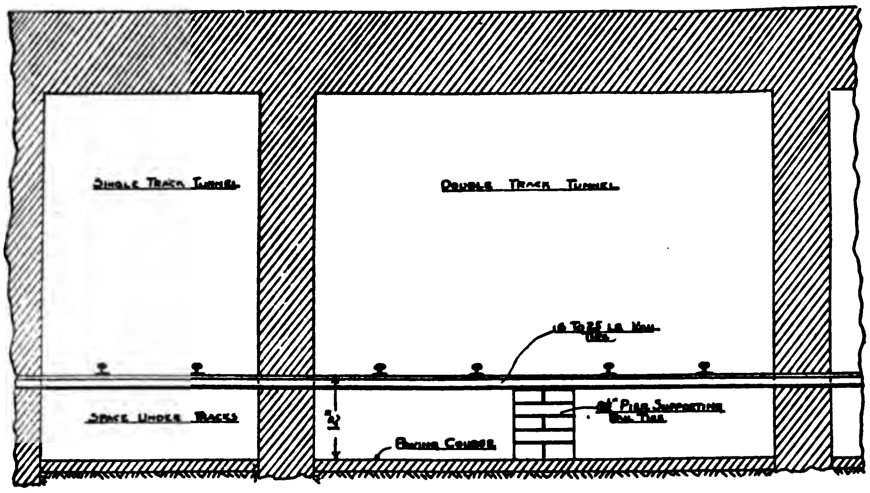


Fig. 5. Showing Details of Single and Double Tunnel Construction.

The grade or fall given the tracks in a dryer is an important item. When too much grade is given the men will "shoot" a car into the tunnel with such force that when it hits the stationary cars, considerable ware is broken or damaged on the way down the line. Too little fall makes it necessary to "bump" the line of cars, much as a locomotive takes up slack, to obtain a start. A grade of 1 ft. in 100 ft. is about right for the average dryer, altho it may be a trifle too much for easy-running cars, and not quite enough for hard-running cars at times. In an open-room dryer the dimensions are not very important, the main point being to keep the source of heat below the ware. In tunnel dryers, where the flow of heat is horizontal or partially so, tunnel dimensions are extremely important. Overlooking this fact produces dryer inefficiency. In order that the heat in a tunnel may do its work properly, the car and ware must fit as tight as is practically possible. Space over the top of the ware should be absolutely avoided, since heated air always rises, and, unless checked, will flow over the top of the ware instead of around and thru it. Not only does this waste heat, but the top courses of ware dry first and often too fast, thus producing heavy losses. In building tunnels, the exact height of a loaded car of ware must be predetermined and only sufficient space left to give clearance. Also, only sufficient space to give good clearance should be left on each side of the cars; otherwise, the air will take the path of least resistance and a large proportion of it will flow between cars and walls without doing any work.

In the design of the lower part of dryer tunnels care should be taken to create a flow of air beneath the cars, also to provide means of getting rid of the ware which is jarred, or falls, from the cars, and which is the cause of so many cars jumping the track.

If steel rail ties are used to support the tracks, it is easy to provide space of 1 ft. below the tracks the full length of the tunnels. This space accomplishes two things: (1) it offers a free path for the air flowing thru the tunnel, which, combined with the natural tendency of the hot air to rise, gives exactly the condition most desired—a circulation thru and under the ware; (2) it allows all ware falling from the cars to accumulate under the tracks instead of on them. This space, even in dryers where there is much loss during transit of cars thru the tunnels, seldom requires cleaning out more than once a year. (See Fig. No. 5 for design of this construction.)

The question of putting one or two tracks in a tunnel is frequently discussed. It is undoubtedly annoying to have a loaded car jump the track in a single tunnel dryer, especially where the cars fit fairly tight. Sometimes, the car will be in such a position that, due to limited working space, it takes hours to replace it. Much of this trouble is eliminated in double track tunnels, since by temporarily clearing one track, space will be provided to enable several men to work around a wrecked car. A well-designed double-track dryer should be as efficient as a single-track type; it is also cheaper to construct.

Doors.

For single tunnels a pair of small outward-swinging doors works nicely; they are light and, since they swing out, a string of cars accidentally started will part and pass thru them without doing them injury. With this type (see Fig. No. 6) the open space left between the rails can be filled in with a 2-by-4 having grooves cut for the wheel flanges. The swinging steel door is not so successful with double tunnel as its weight may cause it to sag and drag on the rails when opened or closed.

The counterbalanced door, which is raised and lowered, is popular where storage space at the cool and hot ends is limited; but it is liable to be battered or broken if the cars in the tunnels start and jamb it.

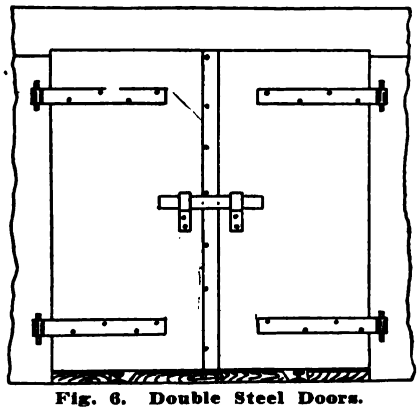


Fig. 6. Double Steel Doors.

Another successful type is the sheet-steel door, hinged at the top and swung open by lifting from the bottom. Cars striking it lift it without doing any damage. It is rather heavy for double tunnels but can be counterweighed. This door can also be fitted tight around the rails (see Fig. No. 7). Suspended hooks are used for holding it open while putting in or drawing cars.

Vent Stack Construction.

The question as to whether a stack or fan is to be used should be decided by a competent engineer, altho the stack, of course, eliminates the fixed operating charge of a fan. Vent stacks built of lumber are not good, permanent investments, while well-built brick or hollow-tile stacks are both permanent and of good appearance. When built of brick or tile, the stack walls should be 8½ ins. thick; and, as a vent stack for a 10-tunnel dryer or its equivalent in width offers a fairly large surface to wind, it is safest to use cement mortar or at least a well-spiked lime mortar.

The varying and fluctuating temperatures of the dryer vapors make it difficult to figure a dryer stack as is done in the case of a boiler stack. Generally, vent stacks are now built about 50 ft. high; if it is necessary to go higher than this, it may be found more advisable to install a fan.

Consideration must be given the fact that the vent stack must span the tunnels or rooms; in other words, that the walls between the tunnels or rooms directly under the stack must carry concentrated loads; also that the stack walls directly over the tunnels must be carried on steel.

Fig. No. 8 shows a standard type of stack for a 10-track dryer having one track in each tunnel. When built of brick, this stack weighs about 90 tons. Including the two outside walls, each of the eleven walls must therefore be built to carry its load safely. The area of the foundation naturally depends upon the nature of the soil upon which it is built. The walls supporting the stack should be laid up in cement mortar. It will pay well to give these details close attention, thus avoiding collapses and costly damage to buildings.

In single-track tunnel dryers, two 3-in. I-beams under each wall will safely carry the load, as each span is short. In double-track tunnel dryers two 6-in. I-beams should be used under each wall. When a 10-track dryer is divided into two rooms, and the steel must span five tracks, four 10-in. I-beams are needed to carry the load, two under each wall.

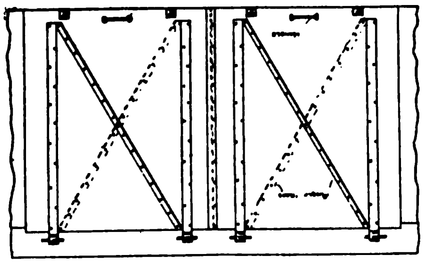


Fig. No. 7. Steel Swinging Doors for Double Track Tunnels.

In cases where ten tracks are put in one large room, an 18-in. square pier should be built in the center of the span; this makes the construction the same as for a five-track span.

Storage and Cooling Tracks.

It is always advisable to have storage room for at least three cars on each track at the cool end and from three to five cars at the hot end. This storage at the cool end allows for fluctuations in the speed of the setters, also for occasions when damp ware begins to show at the hot end and setting must be stopped. With a storage the machine can keep on running on extra cars which can be thrown in on the storage tracks before each tunnel and put into the dryer during the night when dry cars can be pulled.

A good storage at the hot end allows the transfer men to make a pull of several cars from each tunnel at a time, thus saving time and labor costs. The ware gets sufficient time to cool; consequently, it is handled more carefully by the setting crew. Another important factor is that if extra cars are provided the capacity of the dryer can be materially increased. With the dryer full and two or three full cars on each track at the cool end at quitting time, it is easy for the night burners to make one, two or three pulls during the night and put the wet cars in as room is made for them. The system also often provides the little extra dryer capacity needed to keep it in step with the machine and kilns, and, simultaneously, to get all dry ware.

The storage tracks should always be provided with a roof as much of their value is lost if this precaution is overlooked (see Fig. No. 9 for details of such a roof).

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.

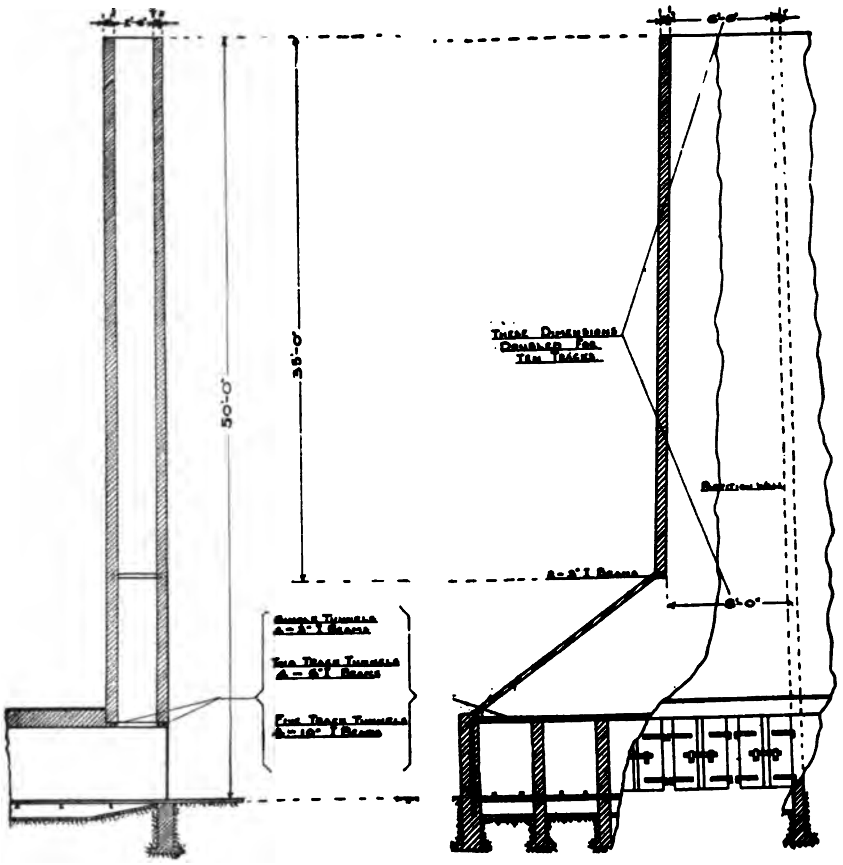


Fig. 8. Detail of Brick Dryer Stack.

MANUFACTURERS' ANNOUNCEMENTS:

Proctor & Schwartz, Inc., Philadelphia, Pa. "Proctor" Continuous Dryers for Refractories, Drain Tile, Face Brick, Glass Pots and all heavy Clay Products as well as Electrical Porcelain, Chemical Stoneware, etc. (See catalog section.)

217—DRYER, FLOOR.—Floor dryers are used to dry any clay ware in the building. On account of the comparatively small capacity, due to the slow drying, and the added expense this system is not used unless it is necessary, or unless the capacity of the plant will not justify the expense of installation for a tunnel dryer.

The ground floor of a floor dryer is usually a hot floor, which consists essentially of spaces or openings beneath the floor into which some form of heat is driven. This form of heat is almost always steam or the products of combustion from a coal fired furnace. When direct fired coal furnaces are used the flues extend from one end of the building to the other or from one side to the other. These flues are covered with brick arches of various thicknesses, the hot part just above the furnace near the fire being thickest and then gradually getting thinner as the flue moves away from the fire. At times sheet iron is used in place of the arches spoken of above, but part of the iron must be protected with brick anyway. The sheet iron cover is also used for a steam hot floor, as the sheets are supported on forming the floor are spaced about a brick piers and exhaust steam during the day and low pressure live steam at night are fed into these spaces. Another form of the steam hot floor is that in which drain tile of about four inch diameter are laid parallel, and exhaust or live steam turned into the ends of them. The tile are covered with a good floor of concrete, which becomes the floor on which to work, and which heats up quickly and thoroly from the exhaust or live steam. The covering over the tiles should be as thin as practical. The upper floors of a building are heated either by the heat from a lower floor or by steam pipes placed just beneath the upper floors. At times the upper floors are slotted, that is, the boards half inch apart, so that the heat will rise and there will be more circulation. Hot floors are used very much for the manufacture of soft mud fire brick, and some for drain tile and fire brick not made by the soft mud process. The dry floors of the upper parts of buildings are used for drain tile of the larger sizes, fire brick and special shapes of fire brick and for sewer pipe.

MANUFACTURERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
International Clay Machinery Co.
Rodgers, L. E. Engineering Co.

218—DRYER, HUMIDITY.—The humidity system of drying can be applied to any type of dryer, as the term humidity drying represents a process rather than a unique form of structural design. There are several vital factors involved in the design and operation of humidity dryers which require special attention, such as: (1) Design of the drying room; this varies with the character of ware to be dried and the allowable velocity of air over the material; the length of drying room is determined by unit output. (2) Loading of material; character of material to be dried determines method of loading, but sufficient area must always be left for free passage of air thru material, to obtain uniform contact between material and air. (3) Method of air circulation; the method adopted should insure a positive, uniform circulation of air thruout the room and an air velocity over the surface of the material consistent with good engineering practice. (4) Quantity of air circulation; this is rated in cu. ft. per min., and will depend upon the temperatures under which drying is to be done, and on the amount of moisture to be removed in a given time. (5) Method of controlling temperatures and humidities; this obviously rests upon temperatures and humidities under which the drying is done. In low working temperatures, which do not exceed 100 deg. F., humidifiers are used to establish a method for controlling the dew-point (or "saturated" air) temperature, and the relative humidity of the air is controlled simply by adding heat by means of steam coils controlled by a thermostat. In high working temperatures, up to 200 deg. F., the amount of relative humidity may be obtained, first, by using a dry bulb thermostat to regulate the depression between the wet and dry bulb temperatures, or, second, by using a hygrostat, which controls the humidity, irrespective of the temperature maintained. In both methods, moisture added to the air is controlled by the admission of steam or water vapor thru a form of spray.

Humidity drying may be divided into three stages: (1) The heating-up stage, during which the material is gradually heated up in an atmosphere of relatively high humidity; this prevents excessive surface evaporation and consequent cracking or distorting of the surface of the material. (2) The drying period, in which the air is heated to maximum allowable temperature for the material being dried, and the relative humidity is gradually decreased to cause the material to be dried uniformly thru its mass. (3) The cooling stage; the cooling should be such that the material will not suffer from too great a variance in temperature while unloading it.

MANUFACTURERS (see catalog section):

American Dressler Tunnel Kilns, Inc.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E. Engineering Co.

MANUFACTURERS' ANNOUNCEMENTS:

Philadelphia Drying Machinery Co., 3351 Stokley St., Philadelphia, Pa. Various types—Automatic Conveyor Dryer, Tunnel Truck Dryer, Stillage Dryer, and Cabinet Dryer (used for experimental purposes, or very small production). Automatic humidity regulators can be attached when required. Assures quick, uniform drying, with reductions in warped and cracked ware; low cost production.

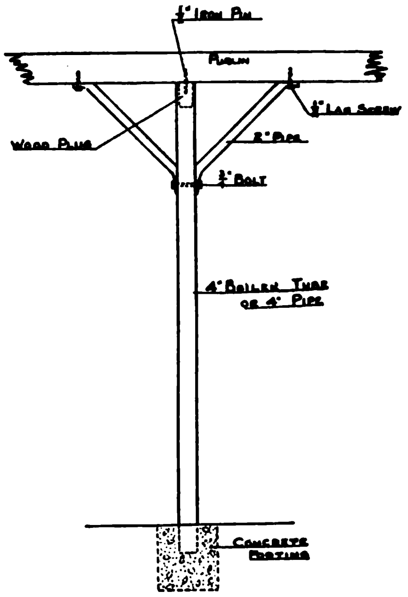
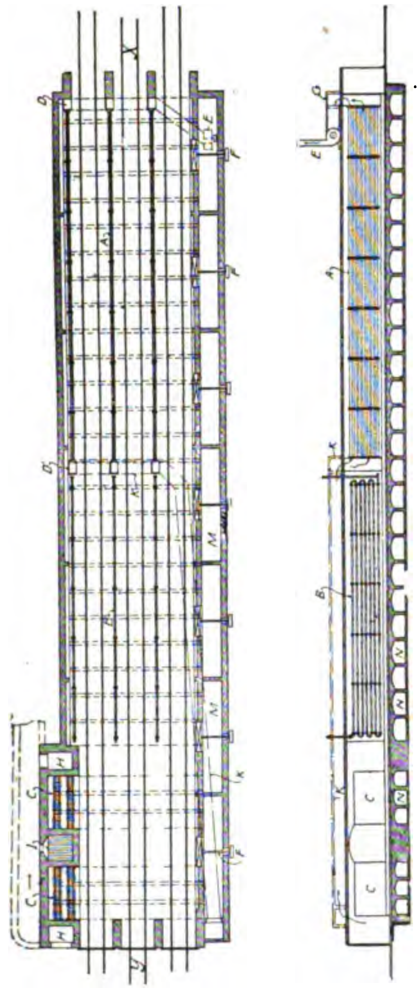


Fig. 9. Detail of Post for Drying Shed.

Proctor & Schwartz, Inc., Philadelphia, Pa. "Proctor" Humidity Dryers—(truck type) for Vitreous Electrical Porcelain, Chemical Stoneware, Saggers, Glass Pots, etc.; (chain conveyor type) for General Ware, Dry Press Porcelain, Filter Press Cakes, Clay Rolls, Spark Plugs, Saggers, Flower Pots, etc.; (rack type) for Sanitary Ware. These machines accurately combine and control circulation, temperature and humidity as definitely required thru the progressive stages of drying each particular material. Their advantages are tremendous to the ends of controlling uniformly correct drying; eliminating spoilage; saving time; and economizing in labor and space.

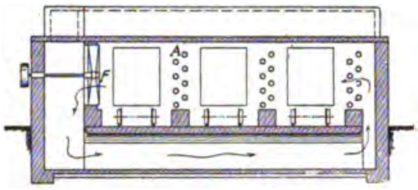
DRYER INSULATION, see Insulation, dryer.

218A—DRYER, MOELLER AND PFEIFER.—These dryers are constructed upon the principle that the air should enter with the ware and that the temperature should advance as moisture is taken up. They are of German design and illustrate the recuperation of heat values in a manner typical of that country's industrial operations. In the plan of construction, a tunnel dryer is used with a direct coal-fired furnace at the hot end of the dryer. This is necessary because the dryer is only partially waste heat, since German operators largely use continuous kilns, in which heat from cooling ware is not available for drying.



Plan and Longitudinal Section of Moeller and Pfeifer Dryer.

The top figure shows the plan of the dryer. The furnace is placed at I, from which the combustion gases pass horizontally thru ribbed radiating flues or tubes C, into flues H, which connect with stack or fan. Several circulating fans, F, are used, one of which is just opposite the furnace. This fan, F, draws the air thru the ware, forces it back under the dryer floor thru ducts N, up around radiating pipes C, and thence thru the ware, the air movement being a continuous rapid transverse circulation thru the ware, with no tendency to a forward movement by the circulating fans.



Cross Section of Moeller and Pfeifer Dryer.

On the roof at the cold end (X) of the dryer, a fan, E, connects with a cross duct, G, and in turn with downcomer ducts, D. The ducts, D, connect with heating pipes, A, which parallel the cars of ware from near the longitudinal center of the dryer to the cold end X. The ends of these pipes at center of dryer enter vertical ducts, D, which connect with a cross and longitudinal duct, K, to the hot end over the dryer roof. The duct, K, enters vertical duct, O, at hot end of dryer, and this duct, O, opens at the bottom into end chamber, M, into which the under ducts, N, discharge. Thus the circuit with the drying chamber is complete.

There are no doors at the cold end, X, and air enters freely at this point. It is immediately taken up by the first fan, F, and the rotary circulation thru heating pipes and ware is started. The suction of fan, E, acting thru the hot end of the dryer, advances air from one fan F to another fan F until the hot end is reached; at this point the saturated, or nearly saturated, air is drawn into duct O, and started back toward E.

Thus, air movement in a Moeller and Pfeifer progressive dryer is that of a spiral with a rapid lateral motion and a slow forward movement. The air, as it advances thru the drying room, is being used to take up moisture and thus dry the ware. When it reaches the hot end, Y, its usefulness as a drying medium is spent, and upon its return thru the ducts and pipes its heat is given up to the incoming air.

Not only is the sensible heat of the air and vapor given up, but, in cooling, a large condensation of water vapor from the highly saturated air is produced, and this returns to the dryer the latent heat required in evaporation.

The dryer losses represent (1) heat taken out by the cars and ware, (2) the small volume of heat in the low temperature saturated exhaust air, and (3) in radiation losses. These losses are supplied by the furnace, I.

If exhaust steam from factory engine is available it may be utilized in radiation pipes, B, between furnace, I, and exhaust air heating pipes A.

In connection with a car tunnel kiln the furnace may be eliminated; and the kiln process will be extended to include heating up and watersmoking, and the waste gases from the kiln will have a temperature of 500 to 800 deg. F. These gases are drawn thru the radiators at hot end of dryer, and will supply the heat normally produced by an auxiliary furnace.

219—DRYER, PERIODICAL. — The periodical dryer, as its name implies, is intermittent in operation; floor dryers, rack dryers, tunnel or compartment dryers belong to this class. The dryer is filled with ware, then the heat and air are turned in and continued until the ware is dry, when they are shut off and the ware removed. The advantages of the periodical dryer may be summarized as follows: (1) It is adapted for the use of lifting cars or trucks, or a conveyor system for delivery of the ware into the dryer and, by the same means, removing it. (2) In some types, it permits slow heating up with as little or as much air as may be desired, and where the ware has reached a condition where it will stand rapid drying, the temperature may be advanced to any degree within the limits of the heating equipment and any required volume of air may be introduced. (See also Dryer, steam.)

MANUFACTURERS (see catalog section):
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.

220—DRYER, POTTERY.—All ware which is the work of the potter is included under this head—whiteware, yellow ware, porcelain, electrical ware, sanitary products, etc. In view of the varying treatment required in the several wares, and because the drying of them requires different conditions, there is no general type of dryer applicable to all.

A modern arrangement for some lines of ware is the continuous operation plan, in which the raw materials enter at one end of the room or plant and advance, with each new stage of manufacture, toward the warehouse for finished ware; this places the dry room adjacent to the manufacturing room and opening into it.

The dry rooms for small ware consist of a series of compartments, each four or more feet wide, depending upon the size of the ware, and ten or more feet long, depending upon the width of the building and the space required for the potters. Shelves, spaced to suit the ware to be dried, are placed on either side of each compartment, extending to the ceiling of the room. The passage way between the shelves is made just wide enough to permit the workmen to pass in and out, in order to get a maximum drying capacity in the allotted space. In some lines of ware the compartments or dry rooms are provided with doors which close the room when it is not being filled or emptied; in others, the rooms are merely racks with suitable passageways provided for the workmen handling the ware. The heating is by steam pipes, commonly three 1-in. pipes along the floor under each set of shelves, or six pipes in each room. In some lines of ware which will stand more rapid treatment, the pipes are distributed under each shelf, or each alternate shelf, which brings the heating surface closer to the ware. Ventilating is natural, crude and very slow, and, consequently, the workroom is heated by radiation. To increase the drying capacity in the same available space, removable shelves are frequently hung on trolleys and overhead tracking.

Another newer type of pottery ware drying room consists of an hexagonal closet. In the center of each closet is a vertical shaft to which the shelves are attached radially, and the whole shelf contrivance can be swung around a circle similar to a laundry revolving clothes horse. This type occupies no greater floor space than either of the former types, and the advantage is claimed for it that it permits the dryer to be placed closer to the potter and thus the off-bearers travel less distance each day.

A new type of drying apparatus for pottery and whiteware is the automatic storeroom, which is operated on the continuous system. This machine is equipped with a sprocket chain, with shelves at proper intervals upon which the ware is placed. The chain moves continually and the ware moved into the drying chamber, which is accurately controlled as to temperature and humidity. The dried ware is taken out of the opposite end by another operator.

It is claimed that the apparatus can turn out about 40 dozen pieces per hour.

MANUFACTURERS (see catalog section):
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Proctor & Schwartz, Inc., Philadelphia, Pa. "Proctor" Automatic Stove Rooms and Mangles—continuous-process dryers for green and dipped general ware—excel for quality of ware, speed and economy of operation.

221—DRYER, PROGRESSIVE. — The progressive dryer is a tunnel or compartment dryer in which the air volume is constant and the temperature remains unchanged, in so far as it is practical to maintain a constant temperature. The theory is to dry the ware in progressive stages by advancing it from a low temperature, usually humid zone, to a high temperature dry zone. In progressive dryers used in U. S., the heated air enters at one end, passes thru the tunnels and escapes at the other end. The ware, usually placed on cars, enters at the air exit end of the tunnels, generally known as the receiving end, and travels thru the tunnels to the delivery end where it is removed from the dryer and taken to the kilns.

The entering air, hot and with great capacity for moisture, first comes in contact with the hot dry ware leaving the dryer. As the air passes thru the tunnels it successively comes in contact with cooler, wetter ware, until, at the receiving end, it passes among the cold, damp ware fresh from the machine. In its passage thru the tunnel the air becomes cooled, thereby lessening its capacity for moisture, yet continuing to take moisture from the damp ware. The dew point is presumed to be reached as the air leaves the tunnel at the ware-receiving end. Under proper conditions, the humidity treatment, so necessary in drying many clay wares, is automatically carried out in the progressive dryer.

The drying condition in the progressive dryer is theoretically ideal. Its construction and adjustment, however, to enable it to meet the highly variable and specific conditions for successfully drying different kinds of ware are matters that require individual and expert attention.

One form of progressive dryer is that in which exhaust steam during the day and live steam during the night, are turned into a set of steam coils. A fan pulls or pushes air thru these coils so that they will give up the heat contained in the steam and the air is then led into the tunnels of brick to be dried. This system of drying is very good in many cases, but the temperature can not go above 220 deg., as it can in the system which dries by the waste heat from the kilns. (See also Dryer, steam; Dryer, radiated heat, and Dryer, waste heat.)

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.

222—DRYER, RADIATED HEAT.—The radiated heat dryer is a development from the direct coal-fired hot floor. The first step was to cover the hot floor with tunnels; the next step was to introduce air around the furnaces and into the tunnels, and then to provide improvements in air circulation and heat radiation. Thus, while the term radiated heat dryer is appropriate, in reality this type of dryer makes use both of convection and radiation. The entering air circulates around hot furnace walls and becomes heated by contact with them; it then passes into tunnels containing ware and gives up heat to the ware and to the work of evaporation. Smoke flues extend full length of the tunnel under the tunnel floor, and thus heat from its walls is radiated to the ware. The furnaces are located in the ware delivery end of the dryer, in a pit below the dryer tracks, and usually and preferably built into the dryer, in order that any radiation from the furnaces, ordinarily considered heat loss, is available in the tunnel for drying purposes. The furnaces are usually simple coal-fired box grates.

Improvements in the radiated heat dryer are directed toward better air circulation and contact with furnace walls, also toward smoke flue construction which will provide maximum radiating surface with minimum wall resistance to the passage of heat by conduction from the inner to the outer surface of the flue walls.

Radiated heat dryers can work with a relatively small volume of air where only natural draft is used; fan draft necessarily requires increased volume. In fuel consumption, fairly representative records show variations from 200 lbs. to 380 lbs. per thousand 9-lb. brick, each brick estimated to contain about two pounds of water; the 380-lb. consumption was attributed to improper construction and inefficient operation.

In design, radiated heat dryers vary with local natural conditions and kinds of ware to be dried, but are usually progressive.

MANUFACTURERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Proctor & Schwartz, Inc.

MANUFACTURERS' ANNOUNCEMENTS:

International Clay Machinery Company, Dayton, Ohio, have devoted years of close study to radiated heat dryers, and are prepared to give expert advice on dryer design for different types of clays and wares. These dryers are so designed to give exact control of the temperature and humidity within the tunnels. See our pages in catalog section.

223—DRYER, RELATION OF AIR TO.—Physical chemistry explains that water as vapor is absorbed by air, and that it goes into solution just as salt may go into solution in water. In drying clay wares, however, we may consider that air does not absorb moisture because air is not an essential factor in vaporization.

If one cu. ft. of air saturated with moisture could be enclosed and the air withdrawn, the moisture would remain suspended in the space as water.

If a long tube, closed at one end, is filled with mercury and the tube inverted in a mercury bath, the mercury in the tube will drop to about 29 in. or barometric pressure. The space above the mercury in the tube is a vacuum. If at this moment a drop of water is introduced in the tube, the mercury will quickly drop; and the fall is not due to the insignificant weight of the water, but to vapor from the water which fills the upper part of the tube and exerts a pressure upon the mercury and depresses it, or more clearly, partially overcomes the atmospheric pressure which supports the column of mercury. If all the water passes into vapor, the saturation of the vacuum may not be complete, and the introduction of more water will result in further depression of the mercury; but when the saturation is complete and no more water will evaporate, then no further change will take place in the mercury level.

Assume, however, that some other liquid is introduced at this point. The space is already saturated with water vapor, but not with the vapor of the other liquid, and the latter evaporates and causes still further depression of the mercury level. The pressure exerted by these vapors is called vapor pressure. Now, if the tube is cooled, a portion of the vapor condenses and the mercury rises; but if the temperature is raised, the vapor pressure (volume of liquid vaporized) is increased, and the mercury falls. If air is introduced, the mercury falls still further, and additional vapor is taken up, due, first, to the greater space, and, second, perhaps in consequence of the introduction of the air.

VAPOR CAPACITY OF 100 CU FT. OF AIR.

	Deg.	Percentage of Saturation						
p′	Fahr.	100	90	80	70	60	50	40
0.361..	50	0.060	0.054	0.048	0 042	0.036	0.030	0.024
0.518.	60	0.085	0.077	0.068	0 059	0.051	0.043	0.034
0.733.	70	0.117	0.105	0.094	0.082	0.070	0.059	0.047
1.024.	80	0.161	0.145	0.129	0.113	0.097	0.081	0.064
1.410.	90	0.218	0.196	0.174	0.153	0.131	0.109	0.087
1.918..	100	0.292	0.263	0.233	0.204	0.175	0.146	0.117
2.578..	110	0.384	0.346	0.307	0.269	0.230	0.192	0.154
3.425..	120	0.502	0.452	0.402	0.351	0.301	0.251	0.201
4.503..	130	0.650	0.585	0.520	0.455	0.390	0.325	0.260
5.859..	140	0.830	0.747	0.664	0.581	0.498	0.415	0.332
7.545	.150	1.051	0.946	0.841	0.736	0.631	0.526	0.421
9.628..	160	1.320	1.188	1.056	0.924	0.792	0.660	0.528
10.850..	165	1.476	1.328	1.181	1.033	0.886	0.738	0.590
12.180..	170	1.644	1.480	1.315	1.151	0.986	0.822	0.658
13.650	175	1.826	1.643	1.461	1.278	1.096	0.913	0.730
15.270	180	2.029	1.826	1.623	1.420	1.217	1.015	0.812
17.060	185	2.250	2.025	1.800	1.575	1.350	1.125	0.900
19.000	.190	2.486	2.237	1.989	1.740	1.492	1.243	0.994
20.260	195	2 631	2 368	2.105	1.842	1.579	1.316	1.052
23 460	200	3 024	2 722	2.419	2 117	1.814	1.512	1,209

Assume, at this point, that one cu. ft. of saturated air was taken from a dryer at 60 deg. F., and the moisture removed by desiccators; by cooling, or in any way, one cu. ft. of rarefied air would be obtained, but less than a cubic foot of atmospheric pressure. Repeat the experiment at 120 deg., and the remaining air would occupy a much smaller volume, and at 212 deg. there may be no air whatever.

In substance, while air in a closed space does not interfere with the weight of moisture taken up, and, in fact, may be in some slight degree an aid, yet in free space the water vapor displaces air and at, or above, the boiling temperature the air may be entirely driven out.

From this it will be seen that, from the standpoint of drying clays, air has practically nothing to do with evaporation; that evaporation is a function of vapor pressure, and vapor pressure is influenced by temperature.

Air plays a mechanical part, and a very important one. Returning to the mercury tube again, assume there is a stopcock in the top of the tube opening into a larger vacuum. When the mercury has reached its lowest level, due to vapor pressure, if the stopcock is opened the mercury will rise immediately and force out the vapor. Closing the stopcock reproduces the former conditions and the water will evaporate as before and force down the mercury. With air, however, we can create a draft and thus sweep away the vapor as fast as it is taken up by space. If the vapor were not removed, drying would cease as quickly as the vapor pressure was attained. As temperature rises, vapor pressure increases, and at 212 deg. equals the pressure of the atmosphere. At this point, air is no longer needed, because steam overcomes atmospheric pressure and forces itself out, not because of air, but in spite of it. This is illustrated by steam rushing out of a boiler, pushing the air away.

Thus, in drying clay wares at low temperatures, it is necessary to use a large volume of air because each cubic foot has space for only so much vapor and must be removed when saturated if the drying is to continue. As the temperature is increased, the capacity to take up moisture increases, and less volume is required to carry it away. Theoretically, above 212 deg. F. no air is needed, but in practice air serves as a convenient, tho not necessarily essential, medium to conduct the heat from its source to the ware.

Frequently the question is asked, "Does the volume of air increase with temperature in equal ratio with the vapor pressure, and, if so, is not the same volume of air required for all temperatures?"

To answer this, the attached table is computed from this formula of Seger for vapor capacities.

$$V = 1.293 \times \frac{P}{760} \times \frac{.623}{1 + at} = \text{wt. of vapor}$$

in kilos per cu. meter of air
1.293 = wt. of 1 cu. meter of dry air at 0 deg. C. and 760 m. m. barometric pressure.
P = tension of vapor at temperature t
a = 0.00366 = co-efficient of expansion of gas for 1 deg. C.
t = temperature of observations
0.623 = specific wt. of water vapor where dry air equals 1

The formula has been changed to pounds, F., etc., and the altitude is assumed to be 800 ft. or 29 in. of mercury, instead of 760 millimeters. The formula thus becomes:

$$V = 1.293\, \frac{p'}{29} \times \frac{0.623}{1+0.002(t'-32)} \times 100 =$$

wt. of vapor in lbs. per 100 cu. ft. of air.

The column at the left gives the value of p′ for several temperatures; the third column is for 100% or complete saturation; the fourth column for 90% saturation, etc. As will be noted in the second column, in advancing from 100 deg. to 200 deg., the capacity for moisture increases more than ten times—namely, from 0.292 lbs. to 3.024 lbs.

The volume of air increases according to the formula $V' = V[1 + a(T - t)]$ in which V' = volume of air at the final temperature T. V = volume of air at the initial temperature t. a = .00366.

This represents an increase of 17% in air volume, or rather the air is rarefied to this extent while the carrying capacity has increased over 1000%. About one-eighth of the air volume is required at the higher temperature to do the same work.

224—DRYER, ROTARY.—There are two general types of rotary dryers, distinguished as direct or indirect heat dryers, both of which are manufactured in a large range of sizes and capacities, adapted to drying clays, shales, sand, marls, slurries, fertilizers, crushed limestone, and for calcining fire clays, roasting ores, and for handling a great variety of other materials from which moisture must be removed at low cost, or in which special heat treatment is required.

In direct heat rotary dryers the gases of combustion are drawn thru the revolving shell and brought in the most intimate contact with the wet materials. They are therefore adapted for drying any materials that will not be damaged by high temperatures or by the gases of combustion from the furnace. Direct heat rotary dryers also remove the largest amount of moisture for the least fuel cost.

The indirect, or radiated, heat dryers are used where the materials would be injured by direct contact with the gases of combustion. In this type the heat for drying is obtained by two methods; that is, (1) the air is heated by being drawn thru steam coils before it is passed thru the revolving cylinder, and (2) the air is heated by the radiation of the heat from a furnace thru the shell of the dryer.

The selection of the particular type of dryer and the length of shell required, must be based upon an accurate knowledge of the nature of the material to be handled, the condition in which it will come to the dryer, the percentage of moisture it contains, the percentage of moisture it is desired to remove, and the approximate number of tons to be dried per hour. Where the capacity is small and the moisture is on the surface, as with sand or crushed stone, a comparatively short shell may be employed with success; but for drying clays or other materials from which a large amount of moisture must be taken, the best results are obtained by using a shell of 40 ft. or more in length.

MANUFACTURERS (see catalog section):
Bonnot Co.
Hadfield-Penfield Steel Co.
Weller Mfg. Co.

MANUFACTURERS' ANNOUNCEMENTS:
Bonnot Co., Canton, Ohio. Rotary dryers from 30 inches to 8 feet in diameter and of any necessary length. Bonnot dryers are of the direct-fired type, suitable for drying any material not injured by direct application of heat.

225—DRYER, SAGGER.—Various methods are employed for drying saggers. In some potteries steam pipes are used, while in others there is a long stove called a sagger flue, which is fired at one end and thru which the heat and flame pass. The saggers are placed on top of this flue, which rests in a horizontal position. Saggers are also dried in automatic storerooms. The reader is referred to Stoveroom and also to Dryer, humidity.

MANUFACTURERS (see catalog section):
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Proctor & Schwartz, Inc., Philadelphia, Pa. "Proctor" Sagger Dryers — continuous-process dryers producing perfectly dried saggers of excelling durability; greatly reducing production time and cost.

226—DRYER, SAND.—In the manufacture of soft mud brick, silica brick and some fire brick shapes, the use of sand on the outer surfaces is necessary. If the sand is damp or wet unnecessary trouble is encountered. The same is true of sand that is used for setting any clay ware. Sand dryers are therefore employed to produce absolutely dry sand. These consist of a large cannon stove which is heated by coal or oil. A wire mesh screen surrounds the stove, and as long as the sand is damp it stays inside of the wire mesh. As soon as it dries, however, it falls out. This type of dryer, therefore, is automatic. In some cases steam coils are substituted for the stove.

MANUFACTURERS (see catalog section):
Bonnot Co.
Stevenson Co.

227—DRYER, SPECIAL FOR STIFF-MUD BRICK.—This system is designed to eliminate the conventional type of dryer for drying stiff-mud brick. Dryer cars, trucks, etc., are replaced by conveyor belts. The take-off belt from the brick cutter is extended along the fronts or ends of the kilns, and a cross conveyor is used to take the brick from the main conveyor and carry them into and thru the kiln, the brick being removed from the belt by the setters. The brick are set six or eight courses high, or to whatever height they will carry the weight, and the floor of the kiln is completely covered to this height. The kilns should be of such size that they will hold one day's run of the machine when piled six or eight high.

The kilns are equipped with underfloor flues. When the kiln floor is fully covered with the first setting of brick, a fan is used to force hot air thru these distributing flues and up thru a perforated kiln floor, among the brick, and out thru the top of the setting.

If the clay will stand rapid drying, the first setting can be sufficiently dried thru the night to carry the weight of a second setting on top of the first lot. In this event, the cross conveyor is raised to the correct height, and the total height of brick at the end of the second day is 12 or more courses. At night, the heat is again turned in, perhaps completing the drying of the first section and sufficiently hardening the second section to permit it to carry the weight of a third section. This operation is then repeated daily until the kiln is filled to maximum height, and the brick are ready for burning, with the advantage that, except for the last setting, they are dry or nearly so, and heated up.

In event the clays will not stand such rapid treatment, two kilns are used alternately, thus allowing 36 hours for drying each section.

This system thus eliminates the take-offs, dryer transfer men and tossers, except that one man is required to remove the waste cut from the belt where cutters making a waste cut are used, and one man is required to transfer the brick from the main belt to the cross conveyor.

This system in its entirety is applicable to up-draft, rectangular down-draft and chambered continuous kilns. The obstacles to its general adoption are due (1) to the fact that few clays in the green state will support the weight of a regular setting, and (2) to the difficulties encountered in trying to regulate the rate of burning to that of drying.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.

228—DRYER, STEAM.—Steam pipe dryers may be divided into two general classes, periodical and progressive.

Periodical Dryers.

A combined radiation and convection periodical steam dryer consists of a series of tunnels with steam pipes laid under the tracks or runways (by means of which the ware is moved on cars, trucks, etc.), and sometimes along the sides. Air inlets and outlets are provided at opposite ends of the dryer. When these air vents are closed the ware can be heated by direct radiation from the steam pipes without the aid of convection. After the ware has been heated and put thru any desired degree of humidity treatment, the air vents may be opened and the drying finished rapidly. With the steam pipes in the dryer tunnels there is practically no loss of radiation. A natural draft is employed and, consequently, very little air is needed; merely enough to sweep out the moisture as it is developed. An ordinary tunnel of this kind is 100 ft. long, and, in some cases, as much as 3,200 lineal feet of 1-in. piping is used to obtain the desired amount of radiation. This size of tunnel holds 7,000 standard brick. Either exhaust or live steam is used for heating.

Progressive Steam Dryers.

In the arrangement of the progressive steam pipe dryer, the piping is massed largely at the ware delivery (hot) end of the dryer; and the air, which enters by natural draft at the delivery end, moves forward horizontally and is drawn off, with the vapor, by means of a suitable stack located at the receiving (cold) end of the dryer. In some cases the large stack at the cold end is replaced by small stacks, about eight inches square, and six or ten feet tall, at intervals in the length of each tunnel. Also in some cases a fan is used on the exhaust end, to pull out the moisture. The dryer itself may be a series of tunnels, each equipped with the proper amount of piping and under individual control, or, more often, it is a large single room. Either exhaust or live steam may be used for heating. The piping is arranged in coils, four to six pipes deep at the delivery end, two to four pipes deep in the next section, and two pipes deep in the section farthest removed from the delivery end. The piping may extend full length of the dryer, or only one-half to two-thirds its length, according to the design.

Pipe Rack Steam Dryers.

The pipe rack steam dryer is simply a series of steam pipe racks upon which flat steel pallets containing the ware are placed. This dryer is used only where the clay will stand such severe treatment. It is customary to build the racks in four sections, each holding 7,500 to 10,000 brick, making the daily capacity of each unit dryer 30,000 to 40,000 brick. The pallets, loaded with brick, are carried into the dryer on rope conveyors which operate in the passageway between the steam pipe racks; the lower or returning ropes are used to carry back the empty pallets.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.

229—DRYER, TERRA COTTA.—It is doubtful whether any dryer may be described as typical of terra cotta. In some cases, single pieces of terra cotta, over 40 ft. long and 10 ft. high, may be modeled, and, after modeling, cut into sections to be dried and burned, each section so complicated that the drying must be watched and controlled individually. Monumental pieces of terra cotta are dried on the modeling floor, and the drying process involves the application of wet cloths here and there on each piece to insure uniform drying without damage. Smaller terra cotta products, such as moldings, etc., can be dried more quickly, and for this reason usually are removed from the modeling floor to some type of dryer. A few of these are described below.

In some plants, the modeling floor (press room) is underlaid by flues from the kilns, and all heat from the burning kilns passes under the floor. At night, hot air from the cooling kilns is forced into the press room to complete the drying. This method is economical, but lacks sufficient control. In other cases, the press room floor is underlaid with steam pipes in sections, each section being controlled by valves.

A typical dryer for ware which will stand more rapid treatment than that of the press room consists of a two-story tunnel. The lower tunnel receives the terra cotta on cars. The upper tunnel is equipped with a fan and a set of steam coils. No outlet or inlet air vent is used. The fan merely keeps the heat radiated from the coils in constant circulation by forcing it thru the length of the upper tunnel, from which it passes into the lower tunnel and returns to the fan.

In some plants this type of dryer has a door in the upper tunnel leading to the fan, an exit door in the lower tunnel, and an opening between the upper and lower tunnels at the fan end as well as at the opposite end. By this means, the fan draws air from the outside, forces it thru the coils to the opposite end of the upper tunnel, then down into the lower tunnel, and exhausts it at the delivery end of the latter.

Another modification of this type is to provide a small relief or escape hole in the top of the upper tunnel opposite to the fan. Consequently, part of the air forced thru the coils by the fan escapes thru this relief hole, while the remainder passes into the lower tunnel, thru the ware, and returns to the fan. The quantity of air which escapes thru the relief hole is, of course, replaced by air drawn from the outside by an inlet placed back of the fan. The lower tunnel doors are kept closed, except in filling and emptying the tunnel, and after the inlets and vents are adjusted to the ware, no further changes are necessary. This dryer produces very satisfactory conditions for drying difficult ware, by providing a rapid circulation of hot and nearly saturated air.

In some terra cotta plants, all ware which has reached the stage of rapid drying and can be removed from the press rooms (which have steam heated floors) is taken to the drying rooms which have slotted floors and thru which the air is forced by a plate fan. The air is drawn from the outside thru heating coils or from cooling kilns; and an arrangement is also provided to permit the hot air, after it has passed thru the dryers, to be forced into the press rooms to maintain the temperature of the latter and provide a nearly saturated air, this being desired for the initial stages of drying freshly molded wares, and also during modeling.

Typical waste heat dryers (see Dryer, waste heat) are also used in some terra cotta plants, and recently humidity dryers have come into use. (See also Dryer, humidity.)

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

230—DRYER, WASTE HEAT.—The progressive waste heat dryer is a tunnel or compartment dryer in which brick, hollow ware, etc., may be dried by waste heat derived from engine exhaust steam, from cooling kilns or from burning kilns; at times two or more of these sources are used in combination to supply the necessary amount of heat. In many cases, direct-fired auxiliary furnaces are also provided to meet any possible deficiency in the supply of waste heat. In design, the object ordinarily is to bring all hot air, whether from steam coils, kilns or auxiliary furnaces, into a mixing chamber adjacent to a forced-draft fan, which supplies the means of convection. Each source of supply of hot air is controlled by a damper. The manner of applying combustion gases and radiated heat from the kilns varies considerably, according to the character of ware to be dried and the individual manufacturer's dryer design. Being a progressive dryer, the green ware enters the tunnel or drying compartment at the receiving end where comparatively low temperature, usually humid, prevails, and, moving forward, gradually meets increasing temperatures and less humidity until, at the delivery end, it is brought into direct contact with the hot, dry blast. In the most modern installations, two fans are used and the dryer may be planned to permit a vertical movement of large volumes of hot air, as is preferable in drying hollow ware, or horizontal movement, according to the design adopted.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.
Rodgers, L. E., Engineering Co.
Steele, J. C. & Sons.

231—DRYER-WHITE.—A term given to the superficial discoloration of clay ware in drying; caused by the adherence of soluble salts to the surface of the ware. (See Soluble salt; Soluble salt, prevention of; and Barium carbonate.)

232—DRYING, HOW IT PROCEEDS.—Clay is porous, and when wet, these pores are filled with water. The pores form zig-zag channels or capillary tubes from the center of the mass to the surface. When there is no drying at the surface, there is practically no movement of the water in the pores—osmotic movement not considered. Immediately, however, that drying begins on the surface, the water thus evaporated is replaced by capillarity, draining the numerous minute reservoirs which we call pores. There is no better illustration than a lamp and wick. As long as the lamp contains oil it will be drawn up by the wick by capillarity. When the oil is exhausted, the flow ceases, altho there is some oil still clinging to the walls of the lamp. Similarly are the pore reservoirs in a clay mass drained. This is the first stage in drying and the stage in which shrinkage takes place, and if all parts of the clay mass are being drained at the same time, there are no unequal or local strains and the ware does not crack.

It is almost needless to say that the safety of drying during this first stage depends upon the relative rate of surface evaporation and replacement.

If we dip different substances in a colored solution and note the rise of the solution in the substances, we will have a clear idea of how in one clay mass, because of its pore channels, the included water will move from one place to another within the mass faster than in another clay mass with a different system of pore channels, to replace water removed by surface evaporation.

Now if the water is evaporated from the surface faster than it is replaced, there must be cracking to relieve the strains, either that or the wet core must be compressed by the dried and shrinking shell, which is very doubtful. To compress such a core will exceed the power of the strongest press, and clay, however strong, has not such strength. There are undoubtedly some strains introduced. It would be folly to claim that drying proceeds absolutely at the same rate thruout the mass, and whenever the strain exceeds the breaking strain of the dried clay, there must be cracking.

In overcoming minor strains, the physical character of the clay plays a part. Ordinary clays, practically all clays, are made up of a number of minerals—fragments of the rocks from which the clays were derived. If the grains are angular and coarse, they may be loosened, partly pulled out of the imbedding matrix, or under compression will rearrange themselves into greater compactness, in either case relieving the strain. Also we must admit that clay has some elasticity which will relieve minor strains.

The safe removal of the moisture then depends upon three factors:

(1) The relative rate of evaporation and interstitial movement of the moisture.

(2) The shape and size of the grains which make up the clay mass—viz., the interlocking power.

(3) Elasticity.

This brings us to the border land of the second stage of the drying, or more properly we should make this the second step in the first stage.

When the drying medium has penetrated to the core of the clay mass, the latter is bone dry, as we say, but there is still the hygroscopic and colloidal water that cannot be removed under the boiling point. Air will take up and hold as vapor a certain amount of water for each temperature. We make this statement advisedly. (Without confusing the discussion with technical matters, let us say the air has absorptive power for the moisture, so, likewise, has other bodies, including clay, and the body which has the greatest absorptive power, will remove moisture from the other. We may say that the clay mass may not become dryer than the drying medium, and air is never absolutely dry. We know that this statement is open to attack, but, relative absorptive powers considered, it is true.)

There is then some moisture remaining, and especially is this the case when we have various salts common to clay besides sulphuric acid lining the pore passages. The latter and calcium chloride are commonly used as dessicators to remove moisture from the air, simply because they have greater affinity for moisture than air. Whatever the cause, some moisture remains in the "bone" dry clay mass which can only be removed by temperatures above the boiling point of water, or of the solution whatever it may be. Sulphuric acid, for instance, is only volatilized at 680 deg. F. The removal of this hygroscopic water is the second drying state and is done in the kilns—water-smoking.

We are not concerned with chemically combined water, since it is never in the form of moisture, and is only expelled by the breaking up of the kaolin at a temperature of 800 degrees or higher. It correlates with the expulsion of carbon dioxide from limestone, or sulphuric anhydride from sulphates, or sulphur from sulphides.

In the water-smoking stage of the drying there is considerable danger. We may generate the vapor so fast that there is considerable pressure, and while it may not rupture the mass as a whole, yet it may loosen the individual grains and thus cause a rather punky product which otherwise would have the steel-like ring so much desired. The grains are loosened in their sockets in the matrix and while they may not pull out entirely, yet they cannot conduct the vibratory motion which is essential if the ware is to ring like steel. A cracked bell or a cracked vase will not ring true, neither will a brick ring true that has an infinite number of minute cracks, or loosened grains. This is why steamed brick are so often rotten.

DRY PAN, see Pan, dry.

233—DRY PRESS AND SEMI-DRY PRESS PROCESS.—Commonly used for producing face brick, fire brick, and common brick. After the clay has been reduced to a finely powdered condition, it is put into steel molds in this nearly dry state, and the ware produced by great pressure. The term, however, is somewhat misleading, as the clay usually contains about 12 to 15% moisture.

In order to produce good brick from any clay, and to avoid losses and cracks the material should be thoroly homogeneous before putting it into the machine. This is usually done by having a mixer containing pins which revolve and stir the clay located just above the machine. The pressure used to make the brick must be almost uniform, as too little pressure makes poor corners on the brick and too much pressure causes a crack lengthwise of the brick on the side.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.

234—DRY PRESS BRICK MACHINE.—The essential parts of a dry press machine are very similar in construction to a brick repress. The molds vary in number from two to six. The pressing mechanism consists of plungers which exert pressure both from above and below when the clay is in the mold, the plungers being operated by cams or toggle-joints which are supported by massive steel framework to give the requisite strength. From a hopper or bin, the clay is fed thru canvas ducts into a small feed box, thence into a charger. The charger holds clay for one charge, and with each raising and lowering of the press plungers feeds this amount of clay into each of the molds, being refilled as it comes to rest beneath the feed box, while the brick are being pressed. In later models of dry press machines, two or three pressures are given each brick. They may be of maximum amount of exertion at each pressure, or maybe two heavy pressures and an intermediate. More than one pressure is given because when the clay is pressed in the mold, air is enclosed in its pores, and if but one pressure is given, this air may, by its expansion when the pressure is relieved, crack or burst the brick. When the intermediate pressure is applied, this permits the air to escape thru vents provided in the die. The final pressure compacts the clay to its maximum density. After the molds are charged and the pressure has been applied, the movement of the lower plunger carries the brick to the top of the mold, where they are pushed forward on a delivery table by the incoming charger. This procedure may be slightly modified in the different types. Ordinarily, both the dies and the molds are steam heated to prevent adhesion of the clay. In addition to the rectangular shape of common brick, the dry press machine may be used to produce special shapes, face and edge designs by the use of special molds and dies. Dry press machines are operated by electricity, steam power or hydraulic pressure, according to type of design. A six-mold dry press has an average capacity of 30,000 brick; and a four-mold, 20,000 brick per day of 10 hours.

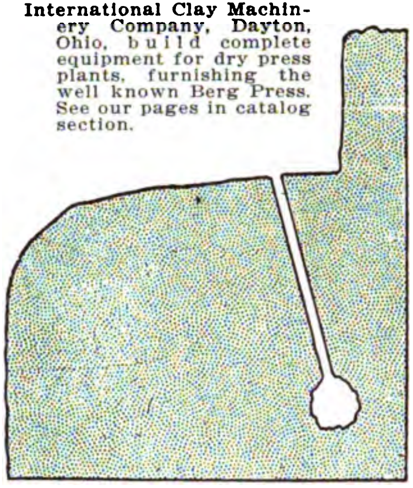
Dynamite Thawing Kettle.

MANUFACTURER (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:

International Clay Machinery Company, Dayton, Ohio, build complete equipment for dry press plants, furnishing the well known Berg Press. See our pages in catalog section.



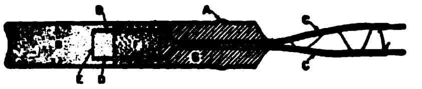
Good Method of Blasting Clay Bank.

DUMP BODIES, TRUCK AND WAGON, see Truck dump-bodies and Wagon dump-bodies.

DUMP CAR, see Car, dump.

DUMPING ATTACHMENT, AUTOMATIC, see Soft mud brick automatic dumping attachment.

235—DYNAMITE.—An explosive formed by the absorption of nitro glycerin with some inert substance such as sawdust or charcoal, and some nitrate compound which assists the explosion. Pure nitro-glycerin is eight times as powerful an explosive as blasting powder, as it forms a gas which, it is said, occupies 10,000 times as much space as it did before the explosion. Dynamite is made in many capacities depending on the proportion of nitro-glycerin contained therein. Dynamite is far safer to handle than nitro-glycerin and is used extensively in blasting operations in the clay products industry. It can be exploded by fuse and detonating cap or electric squib. The latter is safer and to be preferred especially where it is possible to explode more than one hole at a time. At some plants the practice of springing is followed; that is, a small charge of dynamite is put into a hole without tamping in order to create a pocket for a concentrated charge of dynamite, powder or mixture of the two. The theory is that on account of the concentrated location of the charge less explosive is required. On the other hand, it is possible that fissures will be opened up around the hole that will tend to destroy the full effect of the explosive. The advisability of this practice should, therefore, be thoroly investigated in every instance. In mining and digging clay or shale the use of dynamite or powder is necessary unless the material is very soft or power shovels or other digging machinery heavy enough to dig the material as it lays, are in use. Even in those cases the use of explosives often assists to such an extent that its use shows good economy.



Section Thru Electric Cap.

DYNAMO, see Generator and Alternator.

E

236—EARTHENWARE COMMON.—This refers to the lower grades of earthenware, and especially to crockery and the cheaper classes of kitchen utensils. Common earthenware is made of red clays or a low grade fire clay and is usually covered with lead glazes or soft tin enamels. (See also Pottery, a classification of.)

237—EARTHENWARE, HIGH GRADE, CHARACTERISTICS OF.—The characteristics of fine earthenware, according to Sandeman (see "Methods of Earthenware Manufacture") are as follows: (a) In biscuit it is fine, but opaque. (b) In texture and grain it is coarser than porcelain. (c) The fracture is porous, but closer and more refractory than delft. (d) It is neither vitreous nor translucent and is moderately dense. (e) It is sonorous when struck, hard, firm, and durable. (f) For glost firing it is covered with rich, rather than soft, fritted glaze, easily fusible, and containing lead or borax, or both. (g) It should be fine, clear, and free from specks, the glaze transparent, to show its embellishment. (h) It is scarcely affected by acids, alkalies, or sudden alterations of temperature. (i) Fine earthenware requires two fires—the first, or biscuit, fire to make permanent by baking the shape into which it has been formed, and the second, or glost, fire to melt the coating of glaze over the piece. The word biscuit is a misnomer, as it signifies twice baked, whereas the term is applied to the firing of ware in its clay state, which is the first fire. (See also Pottery, classification of.)

EFFLORESCENCE.—This refers to the discoloration that appears on the surface of clay products due to soluble salts. For further enlightenment the reader is referred to Kiln-white; Dryer-white; Soluble salt; Soluble salt, prevention of, and Barium carbonate.

238—EJECTOR.—An ejector is an attachment for raising water out of a pit, hole or sump. The power used is a steam jet, and this type of a jet pump is made to raise water from a lower level or deliver it at a higher level. An ejector will not replace an injector, as the latter is made a little differently for feeding water under a pressure. An ejector is very serviceable in removing water from a fly wheel pit, elevator boot, or similar place around a plant. It is also satisfactory in mine or clay pit work where the amount of water is not large nor the height too great. (See also Injector; Pump.)

239—ELECTRICAL PORCELAIN.—Embraces that line of insulating fixtures made of a mixture of white burning clays, feldspar, and flint. Such articles as wiring fixtures, knobs, cleats, receptacles, attaching plugs, and switch bases are dry press molded. Porcelain used for high-tension insulation, as is necessary for oil switches, transmission lines, and transformers, is made by the wet process, as this class of ware must possess great density and high insulating value. Electrical porcelain is usually glazed. In burning, most of it is fired between Cones 10 and 12, altho sometimes lower temperatures may be used.

MANUFACTURERS (see catalog section):

Engelhard, Chas., Inc.

240—ELECTRICAL PORCELAIN, MANUFACTURE AND REQUIREMENTS OF.—According to Bleininger and Stull, the dielectric strength of a porcelain is proportional to the vitrification area and bodies which are free from mechanical and burning flaws (irrespective of their composition) and which can be well vitrified without warping, would be suited for electrical insulators as far as electrical resistance is concerned. This, of course, does not include bodies containing granular iron nor bodies which contain an appreciable amount of iron. English china clay is excellent because of its regular and gradual vitrification rate. With a mixture of Georgia, Florida, or North Carolina kaolin, and Tennessee ball clay it would be possible to meet practically every condition, and by adjusting the amount of coarse grained materials the drying and burning behavior could be regulated satisfactorily.

The limits of clay substance for insulators should be between 40 and 60%. Alumina has the property of making silicate fusions more viscous and in porcelains it widens the vitrification range; hence, the clay content should not be less than 40%, while 60% is the high limit on account of working and burning qualities.

Feldspar above Cone 8 gives a high development of bleb structure. This is most pronounced in bodies high in flint. Bleb structure is accompanied by low dielectric strength. Hence, manufacturers of dielectric porcelain use high clay and feldspar with low flint. When feldspar is the only flux about 19% is necessary to produce vitrification at Cone 10. The temperatures in ordinary use are Cones 9-12. Electrical porcelain composition is pretty close to the following: (1) feldspar, 30%; (2) flint, 20%; (3) clay, 50%. Probably one per cent. or so of $CaCO_3$ or $MgCO_3$ are substituted for part of the feldspar. Calcined magnesite is better than $MgCO_3$ because CO_2 is likely to cause bleb structure.

Glass or low-fired porcelains (below Cone 9) have not proven satisfactory as dielectrics. This is thought to be due to a heating up caused by the electrical current.

The transformation of a dielectric to a conductor proceeds with an increase in temperature.

High plastic clays can be used, but must be free of granular iron.

Electrical porcelain is manufactured by the fluid casting, dry press and stiff mud process. Mechanical flaws are least apt to occur in the fluid casting process. The dry press product is generally used with low voltages. The stiff mud process is used for purposes as a dielectric. The glaze, usually a dark brown or black, must mature at the same temperature as the body and not be a conductor.

The two main types of insulators are the pin type and the suspension type.

The period of time to which insulators are subjected to test is important. When voltage is brought up rapidly, the test pieces will often stand as much as 25% higher voltages before puncturing than when the voltage is brought up more slowly. The voltage required to puncture is proportional to the thickness of the insulator.

Also, an insulator that would show practically no distress at 150,000 volts, 60 cycles, would puncture in a few seconds if subjected to 100,000 cycles and not over 25,000 volts; this shows the effect of high frequency. It seems that an insulator should stand three times the voltage of a high tension line and show flashing across when high voltage results. It should be also tested for durability under high frequency, say, of 100,000 cycles with a voltage of that ordinarily used. The cycles act as a hammer and produce strains and vibrations which weaken insulators or produce fatigue. Toughness and good elasticity are therefore very important.

MANUFACTURER (see catalog section):

American Dressler Tunnel Kilns, Inc.
Mueller Machine Co., Inc.

ELECTRIC INDUSTRIAL TRUCK, see Truck, industrial, electric.

240A—ELECTRIC KILN AND FURNACE.—The use of electric heat to burn clay ware has not been very successful chiefly because clay is a poor conductor of heat. The kilns in use today all use the flow of the gases of combustion to heat up the ware, altho in a muffle or sagger some of the heat must reach the ware thru radiation or conduction.

Electric heat is produced thru resistance and is localized at one point or in one area.

Electric kilns are in use, however, for putting the glaze on pottery. In this work a kiln or furnace is used that has two compartments, each 4 ft. long by 18 inches wide by 24 inches high. The front compartment is used for preheating the ware up to 300 deg. C. There is a fireclay damper between the two compartments and when the ware has been properly preheated this damper is raised and the ware moved into the second compartment for finishing.

The electric furnace requires no muffle, uses almost 50 per cent. less fuel than oil furnaces, and produces more uniform ware with less breakage.

ELECTRIC MOTOR, see Motor, electric.

ELECTRIC SHOVEL, see Shovel, electric.

ELECTRIC SWITCH, see Switch, electric, standard and safety.

241—ELECTROMAGNET PURIFIER.—Iron and magnetic oxide of iron may be removed from clay by reducing the material to a powder and suspending it in water, so as to give the parts to be eliminated a sufficient mobility to enable them to be drawn by electromagnets. A common method of electrical purification consists of the following arrangement: The material to be purified, being placed in suspension in water, flows in the form of thin sheets thru a trench, above which are placed electromagnets, traversed by a current coming from an ordinary battery. At stated intervals the flow of clay is interrupted, the magnets are removed and placed in a trough filled with water at the side, and the current interrupted to permit the ferruginous particles which have adhered to fall off. Certain earthenware and porcelain factories employ this method for removing metallic iron from the body.

ELEMENTS FOUND IN CLAY, see Clay, chemical analysis of.

242—ELEVATOR BOLT.—Elevator bolts are the bolts used to fasten elevator buckets to an elevator belt. In some conveyors also these bolts are used to fasten the flights to the belt. The bolts are shaped somewhat like a plow bolt, but the heads are thin, flat and round. The diameter of the head is usually about four or five times the diameter of the bolt. This prevents the bolt pulling thru the belt

MANUFACTURERS (see catalog section):

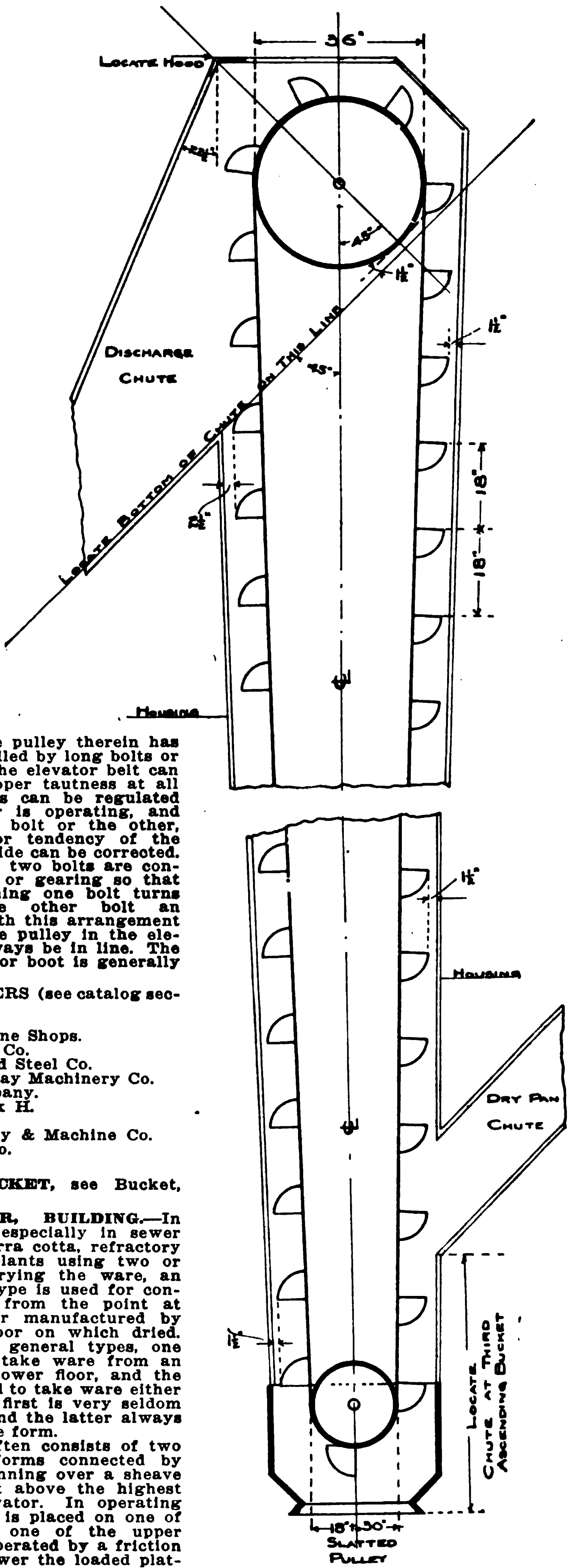
Hadfield-Penfield Steel Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Weller Mfg. Co.

243—ELEVATOR BOOT.—The lower end of an elevator must be protected so that the material which it is supposed to elevate reaches the belt at only one point. To accomplish this the lower end of the belt, pulley, etc., is enclosed in a box of cast iron or steel. This box is called an elevator boot. The pulley therein has its bearings controlled by long bolts or take-ups, so that the elevator belt can be kept at the proper tautness at all times. These bolts can be regulated while the elevator is operating, and by tightening one bolt or the other, any irregularity or tendency of the belt to run to one side can be corrected. In some makes the two bolts are connected by a chain or gearing so that turning or tightening one bolt turns and tightens the other bolt an equal amount. With this arrangement the bearings of the pulley in the elevator boot will always be in line. The pulley in an elevator boot is generally of the slotted type.

MANUFACTURERS (see catalog section):

Bonnot Co.
Clearfield Machine Shops.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Robinson, Frank H.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Mfg. Co.

ELEVATOR BUCKET, see Bucket, elevator.



Clay Plant Elevator.

243A—ELEVATOR, BUILDING.—In many plants and especially in sewer pipe, drain tile, terra cotta, refractory brick and other plants using two or more floors for drying the ware, an elevator of some type is used for conveying the ware from the point at which produced or manufactured by machine to the floor on which dried. These are of two general types, one which is used to take ware from an upper floor to a lower floor, and the other which is used to take ware either up or down. The first is very seldom driven by power and the latter always uses power in some form.

The first type often consists of two elevators or platforms connected by the same cable running over a sheave located at a point above the highest travel of the elevator. In operating this type the load is placed on one of the platforms at one of the upper levels. A brake operated by a friction band is used to lower the loaded platform. The downward travel of the loaded platform pulls the other one up so that when the loaded platform reaches the lowest point or level and is ready to have the load taken off, the empty platform is at the highest level and is ready to be loaded. This operation is then reversed. This type is used chiefly to take ware that has been dried on an upper floor to the kiln.

In many cases, however, the ware is produced on one of the lower floors and must be taken to one of the upper floors for drying, and later taken down again to the kiln. In these cases, a power elevator is used. The power may be derived from two belts driving from a line-shaft, with provision for shifting the belts back and forth and thereby move the elevator upwards or downwards.

An electric elevator is one that derives its power from a motor controlled by a switch placed on the elevator. An electric elevator operates with less vibration than most types. One class of electric elevators does not require an operator and is therefore good for a factory if not tampered with. Electric buttons outside of the doors and inside of the elevator control its entire operation.

A hydraulic elevator is one that has a cylinder directly beneath it sunk into the earth for the same distance as the elevator travels in height. The elevator has a piston of the same length which fits into this cylinder. The elevator is raised by pumping water into the cylinder below the piston, thereby raising the piston and consequently the elevator. The elevator is lowered by allowing the water in the cylinder to escape as the elevator and piston descend.

MANUFACTURERS (see catalog section):
Clearfield Machine Shops.
Stevenson Co.
Toronto Foundry & Machine Co.

244—ELEVATOR OPERATION AND MAINTENANCE.—The most common causes of repeated elevator shutdowns are (1) improper design—which necessitates rebuilding, (2) improper spacing of the buckets, (3) undersized head pulley, (4) too slow or too fast speed, (5) incorrectly designed discharge chute, (6) incorrectly designed feeder chute, (7) loose belts, and (8) failure to clean out the boots.

Buckets should be spaced on 18-in. centers, and for a 9-ft. dry pan should not be less than 6 ins. by 12 ins. in size.

Small head pulleys often cause serious trouble. When the head is too small, the ascending buckets will invariably throw part of their load into the air when they strike the pulley and start over. This is due to the abrupt change of direction, the dust being thrown upwards by centrifugal force. A large percentage of the material thus thrown out falls to the boot and needs to be rehoisted, thereby at times overloading and choking the elevator.

Standard construction specifies 36-in. diameter for the head pulley. Large pulleys and belts traveling at the proper speed insure the material remaining in the buckets until the correct point of discharge is reached.

The proper speed for an elevator of standard design is 325 ft. per minute. This speed is taken from the average dry shale. It may vary as much as 30 ft. either way on some materials.

The discharge chute, if too high or too far away from the buckets, will cause some of the material to fall down again into the boot, necessitating rehoisting.

The feeding chute is nearly always built too low. It should be located so that the material will be fed into the third bucket from the bottom. This allows the overflow to be caught by the two buckets below, thus eliminating the necessity of the buckets digging their load from the boot (see illustration of standard design).

Making buckets dig their own load from an enclosed boot should be avoided—always, since it results in unnecessary consumption of power, the ripping off of buckets and torn belts.

The bucket belt should always be kept tight, and should run on a slotted pulley at the bottom. A slotted pulley will not allow the clay to "build up" on it; therefore, the belt will run true in the housing, instead of scrapping the sides and occasionally stopping thru friction.

"Digging out" the boots twice a day will prevent much trouble, particularly in wet weather or when using damp materials. The dust becomes packed very hard under the buckets and the friction on them gradually increases until they stop. On many plants the boot is never thought of until the elevator chokes, and then only long enough to dig it out until it starts again. Thoroly cleaning all boots at noon and night will save lots of time and temper.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Link-Belt Company.
Robinson, Frank H.

245—ELEVATOR OR BUCKET CONVEYOR.—Bucket conveyors or elevators are used largely for crushed clays. They are commonly formed of a series of small vessels, arranged at definite intervals along an endless belt or chain, so that the buckets dip, at the mean depth of travel, into the material to be carried, and then, filled, convey it to the top of the elevator where it is automatically dumped by the reversed position of the bucket. The power for driving is usually obtained from the main shaft of the grinding mill and transmitted by belts or gearings. The size and strength of the belts and chains, the speed of the belt and the size of the buckets are very important factors, as it is imperative that the capacity of the conveyor equal or exceed that of the grinding machinery, if choking and damaging of the conveyor and loss of production are to be avoided. The pulley at the lower end of an elevator is usually slotted.

MANUFACTURERS (see catalog section):
Clearfield Machine Shops.
Freese, E. M. & Co.
Gandy Belting Co.
Goodyear Tire & Rubber Co.
Green, L. P.
Hadfield-Penfield Steel Co.
Link-Belt Company.
Stevenson Co.
U. S. Rubber Co.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

246—ELUTRIATOR.—An apparatus used for measuring the different sizes of grains found in any sample of thoroly disintegrated clay, by washing, filtering, and decanting the clay, usually thru a series of tube-connected vessels or jars—the process being such that the largest and heaviest grains fall to the bottom of the first jar, the next in size to the bottom of the second jar, and so on until the finest grains are deposited in the bottom of the last jar. The elutriation—or separation—may be accomplished either by creating and maintaining a flow of water thru the vessels until the process is completed or by the use of a continuous air current. (See also Separator, clay, centrifugal.)

EMERY WHEEL, see Grinding wheel.

ENAMEL, see Glaze.

ENAMELED BRICK, see Brick, enameled.

247—ENGINEER, CLAY PLANT.—An engineer for a clay plant is one who by reason of his experience is capable of advising clay products manufacturers as to the best method to pursue in considering the advisability of locating a new plant, or of making additions to an established plant.

A clay products plant to be successful must be operated so as to produce the highest grade of ware with the least expense possible. To do this involves a study of the plant location, the many types of machines, dryers and kilns and consideration of the marketing conditions of the manufactured product.

ENGINEERS (see catalog section):
International Clay Machinery Co.
Rodgers, L. E., Engineering Co.

ENGINEERS' ANNOUNCEMENTS:
L. E. Rodgers Engineering Co., 30 North La Salle Street, Chicago, Illinois; established 1904. Engaging exclusively in the Clay Products Industry. Foremost Designers and Engineers of complete clay working plants. Manufacturers of complete mechanical equipment for Dryers. Rodgers Waste Heat Dryers known as the most economical and successful Dryers in use today; used by the majority of larger Clay Products Manufacturers thruout the country, as well as many smaller ones. Sole Licensee of the Harrop Continuous Tunnel Kiln.

248—ENGINE, INTERNAL COMBUSTION.—An internal combustion engine is one that uses gas, either natural or artificial, or some form of oil as the source of power. If oil is used it must be gasified before or as it enters the cylinder. When gas or oil that is easily volatilized such as gasoline or kerosene is used, the gasified charge mixed with the proper amount of air is exploded by means of an electric spark in the cylinder and this explosion produces a large volume of gases, the expansion of which exerted against the piston produces power. In engines using heavy fuel oil for power, such as the Diesel or semi-Diesel, the fuel is injected into the combustion chamber at the proper time by a mechanically operated pump thru a spray nozzle. This gasifies the oil as it enters the combustion chamber and mixes with the proper amount of pure air, supplied by the pump stroke of the engine. This mixture coming into contact with the hot surfaces and being compressed to a pressure which varies from 225 to 600 pounds per square inch in different makes of engines, ignites the charge and produces the power.

The main difference between a Diesel and a semi-Diesel engine is the fact that the latter uses the lower compression and the former the higher compression which was spoken of above. In addition the semi-Diesel has an easier method of starting.

This type of engine is advisable where the cost of oil or gas compares favorably with coal, taking into account all labor, handling and storage charges. In many locations in remote parts of a plant, for locomotives, transfer cars, trucks, to drive fans, coal unloaders, etc., the ease of their installation and the fact that the installation of a steam or water line is avoided makes their use advisable even tho the cost of the fuel may be a little higher than coal. (See also Fuel oil.)

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

ENGINE OIL, see Lubricating oil and grease.

249—ENGINE, STEAM.—A steam engine is the machine or equipment by which steam generated under pressure in a boiler is used to produce power, thru the expansion of that steam against a piston. There are many different types of engines, all distinguished by name; e. g., stationary, portable, vertical, slide-valve, Corliss, simple, compound, condensing, automatic, etc. Steam engines can be used in every part of a clay plant where steam is available at fairly high pressures.

MANUFACTURERS (see catalog section):
Green, L. P.
Hadfield-Penfield Steel Co.

249A—EXCAVATING MACHINERY.—Under this classification is placed the various machines and equipment used for digging or excavating any class of earth, rock or clay. Some of these machines are used for stripping overburden, others for digging or winning the clay, and others are suited for cutting ditches in the pit or doing contract work such as putting in sewers or farm drainage systems. (See also Shovel, power; Planer, shale; Crane; Digging machinery, clay; Ditching machine; Excavators, drag-line; Gatherer, clay; and Plow.)

249B—ENGOBE.—This term refers to a slip placed on pottery to modify the color of the body or to obtain decorative effects. The reader is therefore referred to Slip glazing.

250—EXCAVATORS, DRAG-LINE.—Drag-line excavators, as the name indicates, are machines for digging or winning clay by dragging a scraper attached to a cable. In many cases where the clay deposit is somewhat inaccessible or peculiarly situated a drag-line excavator is found very practical. A three-drum hoisting engine is usually used. Just in front of the hoisting engine a large timber frame called an A frame is usually erected to keep the cables out of the dirt. At the extreme opposite part of the workings or deposit, "dead men," consisting of heavy timbers, are anchored to the ground to carry the sheaves for the cables. The three cables all run from the hoisting engine to the scraper which travels between the A frame and the "dead men." The scraper is usually about 2½ yards capacity. One cable is used to pull the scraper forward to the engine, the second pulls it backward from the engine and the third cable helps to fill the scraper by adjusting the angle at which it digs into the material and also dumps the scraper after it has been dragged to the extreme end of the trip. Drag-line excavators are used to remove overburden when the haul from the deposit to be uncovered to the "dump" is short. They are also used frequently for digging the raw clay or shale and either hauling it to the factory or dumping it into cars which are later hauled to the plant. When the proper conditions exist, a drag-line excavator is just as economical and efficient as a steam shovel or other machine.

MANUFACTURERS (see catalog section):

Green, L. P.
Link-Belt Company.

MANUFACTURERS' ANNOUNCEMENTS:

L. P. Green, Chicago, Ill., manufactures an improved type of drag scraper which is operated by a two-drum hoisting engine. The scraper is of the bottomless type, and this feature permits it to load and unload without any assistance except that of the operator in changing the pull from one drum to the other. This reduction in operating expense added to the feature of the large capacities attained and the fact that all wearing parts are fitted with easily replaceable plates, renders it the ideal scraper for clay products plants either for digging the material for manufacture or for stripping overburden. When the load line is operated at 200 feet and the return line at 600 feet per minute the maximum capacity is 70 scrapers full per hour for a haul of 100 feet. Other distances in proportion. The scraper is made in sizes from 1/3 to 5 yds.

251—EXPANSION JOINT FOR PIPING.—Long lines of pipe are liable to develop broken or leaky joints, if no allowance is made for the expansion and contraction which is caused by the variation in temperature. This is especially true of pipe carrying steam, as that kind of a pipe has a large coefficient of expansion. To obviate any trouble from this source, safety expansion joints are made a part of many pipe lines. A collar which has a diameter larger than the pipe over which it fits is fastened to the end of one length of pipe in place of the usual coupling or union. It is long enough to take care of any possible change in the length of the entire line of pipe. Packing similar to that used around a piston rod is placed between this collar and the other piece of pipe, and provision is made for keeping this packing snug and tight. The expansion which does occur is taken care of by the pipe and collar sliding back and forth on the packing. In some cases a collar is used that fits over the ends of two adjoining lengths of pipe and packing is used on each end. Long bolts running from one to the other of the ends of this collar keep the packings tight and snug, while the pipe is free to move back and forth as it expands and contracts.

MANUFACTURER (see catalog section):

U. S. Rubber Co.

EXPLOSIVES, see Dynamite; Powder, blasting.

252—EXPRESSION ROLLS. — These machines are used to produce brick from clay that is troubled with excessive lamination when made on an auger machine. The clay is fed to the rolls in a somewhat unpacked column formation and the rolls compress and pack it so that it will pass thru a die built very much like the die on a regular auger machine, but the chief cause of lamination namely the differential flow of the clay caused by the auger is eliminated and this reduces the lamination.

This machine is used in England more than in this country.

EUTECTIC, see Deformation eutectic, and Pottery, materials used in manufacture.

F

FABRIC BELTING, see Belting, fabric.

FAHRENHEIT, see Centigrade.

253—FAIENCE.—Faience is pottery of a porous body, either white or colored, but always covered with a glaze. It is the existence of this glaze which distinguishes it from ordinary terra cotta and the fireproof terra cotta. (This definition, while not universally accepted, is given by E. Bourry in his "A Treatise on the Ceramic Industries;" see pp. 366-7, of Searle's trans. ed., 1911.) Bourry also classifies faiences as follows:

1. Common faiences, with a fusible argillaceous body, in which the fluxes are in a sufficiently large proportion to make the body fusible, without any of them being in an overwhelming proportion. This body is the same as that used for many terra cottas. It is formed of one or more clays, natural or washed, with the sole addition of sand, or grog, if necessary. The glaze is plumbiferous, or alkaline boracic. The principal varieties of this kind of faience are common pottery, architectural faiences, encaustic tiles, stoves, vases, dishes and decorative objects.

2. "Enameled" faiences, with a fusible argillaceous calcareous body, which is formed of a natural marl or of a mixture of clay with marl or with calcium carbonate; the glaze is stanniferous, or plumbiferous. (The term "enameled" is improper here. Sometimes the word stanniferous is used, and this is worse, as the tin is used only to make it opaque, and its presence in a glaze gives no indication of the composition of the latter. The word is therefore used only in default of another, and not to break a terminology which has become customary.)

3. Silicious faiences, with a fusible silicious body, containing a little clay, much silica, and a good proportion of alkaline fluxes or limestone. This very slightly plastic body is, at the present time, composed of silica, with the addition of non-ferruginous plastic clay and lime, or alkalies of different kinds. The glaze is alkaline plumbiferous.

4. Pipe clay faiences, with a slightly fusible argillaceous calcareous body, formed of a mixture of white fire clay and a small proportion of calcium carbonate or marl. The body is decidedly plastic and needs a higher temperature for burning it than the preceding ones. The glaze was formerly alkaline plumbiferous, but now alkaline earthy bases and boracic acid are often added to it.

5. Flint faiences, with a fireproof argillaceous silicious body, formed of a mixture of white fire clay and a large proportion of silica. The body is somewhat plastic and must be burned at a high temperature. The glaze is plumbiferous, alkaline, alkaline earthy, or boracic.

6. Feldspathic faiences, with a slightly fusible argillaceous alkaline body, are usually formed of white refractory earth (kaolin), silica, and an alkaline flux in the form of feldspar or pegmatite. The glaze is plumbiferous, alkaline, alkaline earthy, or boracic.

254—FAN, ELECTRIC, OFFICE.—Office fans are of two main types: (1) bracket fans, stationary or portable, for wall or desk service, and with either oscillating or non-oscillating fans; and (2) gyratory or ceiling fans, which may be attached directly to or suspended from the ceiling. Both types are furnished for alternating current or direct current usage; in some cases they may be equipped with a universal motor which operates on either an a. c. or d. c. circuit. Bracket fans are furnished in numerous sizes, with fan diameters ranging from nine inches upward. Most bracket fans are now equipped with a swivel between motor base and fan, permitting air delivery from any angle desired. Gyratory or ceiling fans are also furnished in many sizes, from fan diameters of 18 ins. upwards. All types of office fans may be equipped with speed control arrangements that give, according to design, from two to six different speeds. Nickel finished or black enameled bases, with highly polished brass, dull brass, or steel blades, are the common finishes. Finish, voltage and cycles, style of mounting and size should be specified in ordering.

255—FAN, HEAVY DUTY.—This class includes all fans used around the plant. Some are of the blower or pressure type and are used to force air under a small pressure, delivering it at or before the point of combustion of the fuel at the boiler, kiln firebox, blacksmith forge or other furnace. This type of fan is generally smaller in diameter, the blades have a smaller surface, and the fan is operated at a faster speed than the suction or plate type. The plate type is used mostly at the dryer or on the drying floor. In most cases one is used to draw air from a cooling kiln or thru a series of steam coils, and one or more used to remove the moist air that has arisen from the drying ware. Whenever a system of sheet iron pipes or other conveyor is used the warm air of the former type of installation can be delivered to any part of the dryer or building, and likewise the suction of the latter type of installation can be pulled from any point.

The plate type of fan is usually used on the hot or kiln end of a dryer. The standard wheel has straight or radial blades, perpendicular to the axis of the shaft. In some makes the blades are pitched back as much as 45 deg.

The disc fan is one that has blades which are curved from the shaft to the perimeter in such a way that the distance occupied on the shaft is very small compared to the diameter of the fan. In this type of fan the flow of air is not changed at the fan, as is done with most types of plate and blower fans. The disc fan is the one generally used for ventilation of a room or building.

The efficiency of a fan depends on the h. p. required to operate the fan and the amount of air delivered at a certain pressure. There is a limit of speed at which a disc fan can be operated and produce good results. A peripheral speed of a mile a minute has been considered the best.

In brick yard practice the plate type of fan has been stated as 45%, the disc fan at 30% and the Sirroco, or multi-blade type of blower fan at 60%.

The limit of speed of the blower type is governed by the strength of the wheel. As the h. p. varies as the cube of the revolutions, it is cheaper to buy a larger blower than to speed up a small one beyond a certain point. The air pressure produced is in proportion to the diameter of the wheel and the quantity of air delivered is in proportion to the width of the wheel.

Disc fans are used for ventilating mines in many cases. Disc fans are also used almost exclusively in humidity dryers.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Philadelphia Drying Machinery Co.
Rodgers, L. E., Engineering Co.

FASTENERS, BELT, see Belt fasteners.

FAT OIL, see Oil, fat.

256—FEEDERS AND MIXERS, CLAY.—Clay feeders are attachments to use in connection with any machine or equipment where a constant and continuous supply of clay is desirable. They are found to be most useful in feeding the dry pans and pug-mills. Some types feed by means of a revolving disc, others by means of a screw conveyor, still others by means of an oscillating bed at the bottom of a bin, and still others by means of a reciprocating plate or a revolving apron. In some plants a belt conveyor, running beneath a bin, is used with short removable planks covering the conveyor. The feeders for wet pans generally consist of hoppers containing one charge or pan load.

Clay mixers are the machines that are used to make the clay uniform in quality. Several types of digging machines are built with the idea of cutting or digging the clay or shale in vertical layers, thus insuring a uniform mixture. Other types of machines are built to mix the clay after it has been delivered at the plant. These usually consist of a screw conveyor or of a hopper with horizontal arms revolving around a vertical shaft. Swinging arms are hung from these horizontal arms and they drag in the clay and mix it thereby. Some mixers are built like a pug-mill or pulverizer with horizontal shaft. (See also Poidometers.)

A belt conveyor is usually employed for feeding a steam press, making either drain tile or sewer pipe. This is a short belt onto which the tempered clay from a wet pan or other preparing mechanism is dumped. This type of feeder must work intermittently, that is, it is idle from the time the piston of the press starts down on its stroke until it is again at its highest point. When the piston is at its highest point the belt must operate so as to quickly fill the clay cylinder, in order to keep the press idle as short a time as possible.

MANUFACTURERS (see catalog section):
Clearfield Machine Shops.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Robinson, Frank H.
Schaffer Engineering & Equipment Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

MANUFACTURERS' ANNOUNCEMENTS:
Schaffer Engineering & Equipment Co. Pa. Investigate the Poidometer. It feeds by weight and its accuracy is guaranteed.
Stevenson Co., Wellsville, Ohio. Mechanical Feeders for charging crushers and dry pans. Wide range of sizes and capacities. A MEMBER OF THE STEVENSON LINE—WHAT MORE NEED BE ADDED!

257—FEEL TEST, THE.—This is the primary means to which a prospector resorts to ascertain the texture and plasticity of a clay. It consists simply of rubbing the powdered dry clay between the fingers to learn something of its texture and grain. Between the teeth, the degrees of grittiness can be detected; this is quite a reliable way of distinguishing arenaceous and fine-grained clays. If wet with water, clays become soft, and a plastic clay will have a soapy or greasy feel when rubbed with the fingers. Sandy and coarse-textured clays do not exhibit this unctious or oily nature to the touch and are less cohesive and less capable of being molded. A very unctious clay is said to be "fat;" a sandy, non-cohesive clay, "short" or "lean."

258—FELDSPAR.—Feldspar is one of the most important ingredients in a pottery body, and the one of which it is most desired to have a chemical analysis. It is a mineral of a number of varieties, having the general formula RO Al_2O_3 $6SiO_2$, the base RO being potash, soda, lime, magnesia, or a combination of these. Its color varies from white or pale gray to drab and light red, the pink variety being in most demand. It is obtained from igneous intrusions of varied irregular structure, and the material mined must be carefully sorted.

Orthoclase or potash feldspar is the most important variety. Microline, albite, oligoclase, labradorite, andesite, anothite and sodalite also occur in considerable quantities. Feldspar is the constituent which cements the body of the ware together at high temperatures. From 15 to 25 per cent. is the usual quantity used in pottery mixes. It is also used in glazes and melts at about 1300 deg. C.

259—FILTER PRESS.—The type of filter press in common use in earthenware potteries in U. S. has cast-iron chambers of from 72 to 75 leaves or chambers each, the rail plates being either round or square, according to type of construction. The round rail plates are about 28 ins. in diameter; the square plates about 24 ins. square. Between the iron plates (or chambers) of the filter press, canvas sacks are placed, and between these sacks the clay is deposited by pressure of the slip pump which is used to handle the clay slip between the smooth agitator and the filter press. When pressure is applied to the plates, the water is forced from the clay and is discharged thru the canvas, leaving the clay in each chamber between the two sacks. The iron plates are then pulled apart and the cakes of clay, now of about the consistency of putty, are removed. An average pressure is maintained at the pump, so that when the filter press becomes well filled the surplus liquid clay passes back to the safety valve or overflow into the smooth agitator, thus eliminating danger of breaking the filter press by too much pressure. The standard clay cake coming from the filter press is about 1¼ ins. thick and weighs approximately 42 lbs. From 72 to 75 of these cakes are delivered at a pressing, and an average of three to six pressings are made daily in modern plants.

MANUFACTURERS (see catalog section):
Bonnot Co.
Celite Products Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Newark Wire Cloth Co.

260—FILTER PRESS PUMP.—The filter press pump is a special force pump used in pottery plants to pump the liquid clay slip from a smooth agitator to a filter press, the filter press being used to squeeze out the water and press the clay into cakes of uniform size and of about the consistency of putty. A filter press pump must be capable of working against great pressure and be equipped with a safety valve to allow the overflow from the filter press to pass back into a special tank. To prevent ramming, a 3-ft. pipe, closed at one end, is attached to a T-joint in the supply pipe between the filter pump and filter press; this acts as an air cushion which absorbs a large portion of the excess pressure. Filter pump fittings require persistent attention, as, due to heavy pressure and constant contact with clay, they wear rapidly, and unless they are kept in prime condition they will waste time and clay by leaking.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J. Does not churn air into slip, filters better, saves filter cloth, uses less horse power. Automatic pressure regulator is part of pump and is absolutely reliable.

261—FINANCING.—This refers to the act of controlling the money matters of a plant to such an extent that it is always solvent and able to operate at as full capacity as is possible, depending on the demand that exists for its output. Of course the better the financing the larger the profits will accrue. Good financing means ability to meet and pay all debts and obligations on the date they are due. Good financing further requires ability to borrow money at the proper time and in the proper amounts, and a definite knowledge of when and how that loan will be paid off. This is true whether the loan is in the form of a bond issue or a secured or unsecured note. Discounting all bills is one form of good financing.

262—FIRE ALARM.—The standard fire alarms to notify the fire department of the city will not be considered here because they are usually furnished by the municipality. Fire alarms for notice to employees, etc., are either electric or connected to the automatic sprinkler system. The electric signals are either bells or an industrial signal similar to those used on automobiles and trucks. The latter, when high powered, can be used at night to arouse the workmen who live close to the plant. This latter feature is valuable when the employees at night do not number enough to fight the fire successfully. When a room or building is crowded with employees and the exit is comparatively small some kind of a fire signal is necessary to warn the employees in proper time and without excitement. An automatic sprinkler system can serve as a signal thru the pressure or flow thru the pipes. A sprinkler system consists of valves on the outlet end of pipes distributed at many points. These valves are kept closed by metal caps, part of which cap melts at a predetermined temperature, allowing the water to flow thru the valve or opening in order to put out the fire. (See also Fire prevention apparatus.)

263—FIRE BRICK.—These are made in a variety of shapes, and also differ greatly in density, hardness and texture, according to the class of service for which they have been made. For abrasive resistance they must be very hard; to resist corrosion they must be dense; to resist high heats and changes of temperature, porosity and coarseness are essential.

Fire brick are made from one or from several grades of clay, to which is added in some cases a certain amount of ground fire brick or, more rarely, coarse quartz. Some plants use a dry pan or disintegrator to prepare the material for the pug-mill; others use a wet pan to combine the crushing and tempering operation. Occasionally, where soft clays are used, the tempering is done in a ring pit.

Fire brick, altho originally molded entirely by hand, are now produced largely by either a soft mud or stiff mud brick machine, and some manufacturers specialize in dry press brick.

The method of drying varies with different manufacturers (see Drying, Dryer), but the burning is done almost entirely in down-draft kilns. It is noteworthy that the temperature range for burning fire brick in different plants varies from Cone 5 to Cone 14. It is now generally conceded that the refractoriness of a fire brick depends, first, on the total quantity of fluxes present; second, on the silica percentage; third, on the coarseness of grain. (See also fire clay in classification of Clay and Refractories.)

FIRE CLAY, see fire clay under classification Clay.

FIRE EXTINGUISHER, see Fire prevention apparatus.

264—FIRE PREVENTION APPARATUS.—Water, of course, is the common method of putting out a fire. In some cases, however, water is not available, and quick action is necessary. Under those conditions, a chemical put up in the proper container is essential. Some of these are made to be carried by hand and some are loaded on a truck. In addition, however, every plant should have adequate water supply for fighting a fire. A sprinkler system, which is automatic, is very good, and there should be hydrants with ample hose supply at convenient points. These hydrants should be connected with the city mains, with a large overhead tank, or with an automatic fire pump. (See also Fire alarms.)

MANUFACTURER (see catalog section):
U. S. Rubber Co.

265—FIREPROOFING.—This is the term given to those forms of hollow ware which are used in the construction of floor arches, partitions, and wall furring for columns, girders, and other purposes in fireproof buildings. A number of different shapes and sizes of fireproofing are made, the most of them being 12 ins. long but varying in the other two dimensions. Ordinarily, fireproofing hollow ware may contain one or more cross-webs or partitions to give it strength and ruggedness.

(See also several items on Hollow block and Die, factors of operation.)

MANUFACTURERS (see catalog section):
Celite Products Co.
Hadfield-Penfield Steel Co.

266—FLANNELING.—After earthenware pieces or china or porcelain have been formed from the clay, they are allowed to dry thoroly, after which each piece is looked over, its edges and surface being rubbed smooth with a piece of heavy flannel; this is called flanneling. If any of the articles are found to be cracked, they are discarded and the material is usually again put thru the slip-making process. If, however, the clay has been touched by fire it is useless for any further purposes.

267—FLASHING.—Many bricks used for fronts are often darkened on the edges by special treatment in firing, caused chiefly by setting them so that the surfaces to be flashed are exposed to reducing conditions, either at the end of the firing or during the entire period of burning. This is called flashing. The color caused by flashing is superficial and may range from a light gold to a rich, reddish brown. The principle of operation depends on the formation of ferrous silicate and ferrous oxide and their subsequent partial oxidation to the red or ferric form. This oxidation probably takes place during the cooling process; for, if the kiln be closed so as to shut off the supply of oxygen, the bricks are found to be a light grayish tint.

The degree of flashing is affected (1) by the composition and physical condition of the clay, (2) the temperature of burning, (3) the degree of reduction, and (4) the rate of cooling and the amount of air then admitted to the kiln.

268—FLATWARE PRESSING.— Refers to the hand process of modeling oval meat dishes, pudding dishes, comb and brush trays, irregular shaped bonbon dishes, etc. The process is just the reverse of hollow ware pressing (see Hollow ware pressing, processes of), as the inside or upper surface of the article is made by the mold and the outside by hand pressure.

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

269—FLINT.—True flint is an amorphous form of silica. It is calcined and wet ground, and used extensively in England in the production of refractories. In this country the chief use in ceramics is in the manufacture of pottery. For this purpose ground quartz sand from Illinois or sand rock from Pennsylvania are commonly used. Flint is used largely in pottery to reduce the shrinkage in drying and during the firing and gives to the body a certain rigidity, opposing deformation due to softening. At the same time it permits the escape of steam, carbon dioxide, and other gases during the previtrification. (See also Silica; Refractories and Pottery, materials used in manufacture.)

FLINT CLAY, see description under the fire clay entry in item Clay.

FLOOR BRICK AND SHAPES, KILN, see Kiln floor brick and shapes.

270—FLOOR TILE.—This class includes tile of a great variety of shapes and colors, all used for flooring, and all possessing, therefore, sufficient hardness to withstand abrasive action, sufficient transverse strength to resist knocks, and sufficient density to prevent excessive absorption of water. As a rule white tiles have little, if any, absorptive power; but, among the other colors, it has been shown that some will absorb one per cent. to five per cent. of moisture, and probably more.

It is of the utmost importance in selecting the raw materials for floor tile that the nature of the clays be such that they will not form surface cracks after being air-pressed; the clay should also be free from any tendency to warp or split in burning. Where the mixtures for facing and backing are different, it is imperative that they be properly adjusted. The clays should likewise be as free from soluble salts as those used in the manufacture of pressed brick or terra cotta, altho as Langenbeck pointed out (see Chemistry of Pottery, p. 155), soluble lime salts may result from the coloring materials used. Consequently, the manganese and umber used for chocolates, brown and black are rarely free from gypsum. Purdy has suggested (see Trans. Amer. Cer. Soc., VII, p. 95, 1905) that floor tiles be separated into two main classes, each of which is further subdivided as follows:

1. Face tile: Class A is vitreous and white colored; Class B is porous, with clay colors. Both classes commonly have a prepared facing body on a common clay backing.

2. Tesseræ: Class A is vitreous, white colored; Class B is encaustic, with clay colors. Both classes have solid bodies formed into geometric shapes.

White floor tile are commonly made of a mixture of white burning clays, flint and feldspar. Buff-colored tiles and artificial ones are derived from fire clays, while red tiles are frequently made from a red burning clay or shale. A certain percentage of flint and feldspar is usually added to the clay to regulate the shrinking or degree of vitrification in burning.

Floor tiles are molded in handpower machines by the dry process, the raw materials first having been thoroly ground and carefully mixed. In burning, the tiles are placed in saggers and burned in down-draft kilns.

Face tiles include the plain or Alhambra 6-by-6 tile strips of various sizes, such as the 6-by-3 and 6-by-1½ used as body tile; they are generally made with a prepared facing body backed by a common body, the latter being ground to a 16-mesh powder in a dry pan. In making plain floor tiles, the die is first covered to the required thickness with the facing body and the remaining space filled in with the backing clay, after which the pressure is applied. For making inlaid face tile, a brass cell frame of the same depth as the facing body is used; it consists of a framework of brass strips which are arranged to form the outline of the colors in the pattern. The framework having been placed in the mold, the colored clays are sifted into their respective positions; this, of course, necessitates using as many sieves as there are colors in the design. The cell frame is then lifted out and the die is filled with a clay backing, preparatory to applying the pressure.

In the manufacture of tesseræ the body is solid; that is, made entirely from one body mixture. The vitreous tesseræ are porcelains, of such compositions as to promote the greatest toughness or resistance to wear under feet that it is possible to obtain with the texture of the body and the brilliancy of colors demanded by the trade. Encaustic tesseræ tiles employ buff or red burning clay for their base. Because of the iron content in these clays, mainly present as free oxide, it is impossible to burn these tiles to vitrification without destroying the color.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.

271—FLOWER POT MACHINERY.—Flower pot machinery, or the machine which finally forms the pot, generally is similar to a drill press in appearance. There is an upright casting which looks like a pillar. Onto this casting is fastened the outside mold for the flower pot in much the same place as the swinging plate or bed of the drill press is fastened. The core or inside part of the mold is placed on the end of a continuous revolving shaft in very nearly the same place as the drill in a drill press. Similarly, the shaft holding the core slides vertically in its bearings under control of the operator. The clay is prepared under different processes depending on its quality and nature, and then run thru a small auger machine which produces a column that can be cut off in the required lengths so as just to fill the flower pot mold. A special oil is mixed with the clay during the preparation.

MANUFACTURERS (see catalog section):
Baird Machine & Mfg. Co.
Hadfield-Penfield Co.
International Clay Machinery Co.

FLOWER POT PRESSING, see Jiggering and jollying.

FLUE CLEANER, see Cleaner, boiler tube and flue, mechanical.

272—FLUE GAS ANALYSIS APPARATUS.—Complete and even economical combustion requires that the utmost economy be attained in the kilns and boilers of every clay products plant. We speak of economical combustion as different from complete combustion because complete combustion can be achieved at times only at greater expense than the possible saving it can show. All fuel, however, should be burned to develop all the heat units possible, and a flue gas analysis apparatus is an instrument or device that shows what results are being attained along that line and what room there is for improvement. The instrument takes a sample of the gas in a boiler breeching or kiln flue thru a rubber tube. This gas is pumped thru certain chemicals contained in glass tubes, each one of which absorbs one component of the flue gas. The most important are Carbon dioxide (CO_2) and Carbon monoxide (CO), and the relation or proportion of these two gases indicates the efficiency being shown in the fuel combustion. A small proportion of the former shows too small a supply of air, and vice versa with too large a supply. Full instructions accompany every instrument.

273—FLUORSPAR.—The fluoride of calcium ($CaFl_2$), which is used as a flux by potters. It decomposes at a red heat the lime combining with the other elements of the glaze. (See also Calcium Fluoride.)

274—FLUX.—A flux is a eutectic mixture in a clay body which becomes liquid and takes the other substances present into solution when a certain high temperature has been reached.

The popular conception of a flux is that of a solid substance which, when blended with a more refractory solid, will cause a lowering of the melting point of the latter substance, or, in other words, that will increase the ease of fusion of the other substance. Sodium carbonate when blended with clay makes possible the liquefaction of the clay.

Substances used in porcelains to produce vitrification are feldspar, cornish stone, calcium fluoride, calcium carbonate, magnesium carbonate, cryolite, calcium phosphate, glass, frit, zinc oxide, lead oxide, talc, etc.

275—FOOTWEAR.—Footwear is an important item for every employe around a clay products plant, as practically all of the laborer's work is done while he stands on his feet. In mine and pit work it is often necessary to use either rubber or felt boots. Either will keep the feet dry, and the latter will keep them warm also. In the plant it is often necessary to stand on concrete, or what is worse on a hot floor, and in the kiln yard a man's footwear must be able to withstand water, snow, heat, cold, cinders, etc. The high price of leather has reduced the quality of sole leather, so that the composition material which has been put on the market as a substitute can be bought at the same price and it will last longer. Rubber is a constituent of all of these compositions, and that is why they are better suited for very severe service, of every nature. Their use is growing continually. See Hand leathers.

276—FORCED DRAFT.—Forced draft is the term used to denote the use of air under pressure at or before the point of combustion of the fuel. The pressure usually amounts to only a few ounces. A pressure fan or blower is used in most cases. This system is the foundation of several improved types of kilns and fireboxes. It is very efficient also in power plants where the fuel is of low grade, the draft is poor, or the boilers must be overloaded. (See also Fan, heavy duty, Blowers, Kiln fire box and both entries under Stoker.)

277—FORGE.—A forge is a furnace in which metal is heated. Blacksmithing coal is commonly used altho gas and oil are employed in some cases. Air is supplied under a slight pressure to concentrate the heat at one point. The stationary forge is built of brick with a chimney. Portable forges are often used for repair work around a plant. These consist of a hearth for the fuel and a blower operated by hand all mounted on a portable frame. Naturally the portable forge is limited in the size of the work that it can do, but it is a necessity for babbitting bearings in the plant, and is suitable for sharpening and tempering tools, heating rivets, welding and forging of small pieces, etc. The oil-fired forges are made for continuous use at one class of work like heating rivets, making small tools, etc., and do not find much use in clay plant operation. They are usually built with a steel shell and a fire brick lining.

278—FOUNDATIONS.—The question of foundations is too exhaustive to permit of full discussion here, but it is too important to permit of only passing notice. Under Kilns, continuous, design and construction of foundations, we have gone into the matter very fully and the reader is referred to that item concerning any kiln foundations as the principles involved are the same in every case. Poor foundations are the cause of much loss and trouble in kiln operations. It is more common than it ought to be, to find a down-draft kiln constructed with good foundations under the walls and really no foundation under the floor, as if the construction of the flues and floor constituted all of the weight that that part of the ground had to hold. A good foundation under the floor is just as necessary as it is under the walls or under any building. The large number of broken brick or cracked or warped ware that is found in many kilns can be traced directly to the settling and warpage of the bottom of a kiln, which could be prevented by a good foundation. The shrinkage of the ground upholding the floor due to the heat that is carried down also causes settling of the floor and for this reason a kiln foundation should never be built on sloping ground. The calcining of the higher ground will cause uneven settling of the floor of the kiln. Kidder's Architects' and Builders' Pocket-Book has very exhaustive discourses on the subject of foundations showing practically every phase of the subject and the reader would do well to read that part when contemplating any construction work. In that volume the testing of the ground beneath the contemplated structure is advocated, and this is especially timely for clay products plants because many buildings and kilns are put up on ground that has been made by the accumulation of refuse cinders, etc. A six-inch auger should be used and the borings run down six feet below the depth to which it is intended to place the foundation. The bottom of any foundation must be below frost line if serious trouble is to be avoided. Moreover, in building a stack the load to be placed on the ground per square foot should be less than for a kiln or building. This is because of the fact that the height of the stack in proportion to the area of the base is so much larger than it is in the case of buildings. Any uneven settling of the foundation in the case of the stack will result in throwing the stack out of plumb if it does no worse, and often will cause the cracks that are found in so many stacks running around the stack and also up and down. On account of the expansion of the inner lining and also on account of the fact that so many stacks work on the intermittent principle, that is, they heat up and cool off at every burn of the kiln, stacks are subject to forces and causes that do not have any bearing on ordinary buildings. The reader will find a table in the statistical section that will show the allowable loads for various types of soil. In the case of kilns and stacks it would be advisable to allow less than that amount. Satisfactory kiln foundations have been built by putting in a good foundation of concrete and at times placing old iron, rails or pipe in the concrete and covering the concrete with from 18 to 36 inches of brick work placing good fire brick on the upper courses. If this foundation extends to include both walls and the inside of the kiln the repairs that will be found necessary will more than pay for the cost of the concrete. (See also Concrete.)

279—FREEZING TEST.—Clay products should resist the action of freezing. A method of testing their resistance to this action is to saturate a specimen of ware in cold water and place it in a refrigerator so that all sides of the ware are exposed to the cold air for about three hours or until completely frozen, and then removed and placed in water having a temperature of 100 deg. C. (212 deg. F.). After being allowed to remain in this water for several minutes, the ware is again removed and refrozen as before. This process may be repeated up to 20 times, depending upon the exhaustive nature of the test. Observations are made as to cracks formed, etc., and the piece is then dried at 110 deg. C. (230 deg. F.), and the crushing and transverse strength tests made. These pieces are then compared with pieces that have not been frozen and the loss in transverse or crushing strength calculated.

FRICTION CLUTCH, see Clutch.

FRICTION COUPLINGS, see Coupling, shaft.

280—FRICTION, TRANSMITTING POWER BY.—Power is transmitted by friction by keeping two surfaces in contact, one being the driving surface and the other the driven. These surfaces are usually cylindrical or beveled and greatly resemble gears and pulleys—they are in fact gears without teeth. A pressure is exerted thru a spring or by other means which keeps the two surfaces in contact and makes them act in conjunction just as if they were equipped with an infinitesimal number of teeth. Friction transmission is especially suited where it is desired to obviate noise, and proves more satisfactory for lighter drives than for the heavier drives. The contact surfaces are made of any pliable substance which withstands wear.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
Link-Belt Company.

281—FRIT.—A semi-fused composition usually formed of silica, borax, lime, soda ash, etc., that is used as a basis for glazes. These compounds are first mixed and then fused into a molten liquid which is permitted to run into a water bath and thus cooled and cracked so as to permit easy grinding. The object is to produce insoluble silicates from the otherwise soluble compounds such as borax, soda, etc. (See also Glazing materials, how to prepare.)

282—FRIT BRICK.—A lump of calcined glass materials, brought to a pasty condition in a reverberatory furnace, preliminary to bringing about perfect vitrification in a melting pot.

283—FRIT KILN.—Used in the preparation of frit for glazes. (See Glazing materials, how to prepare and Kiln, frit.)

284—FROGS, RAILS AND SWITCHES.—Modern clay plants are, in increasing numbers, adopting light track rail systems for carrying clay from pit to plant and for practically all other types of hauling between fixed points of transportation. To meet the widely varying demands for all classes of hauling, rail manufacturers are now supplying light rails that range in weight from 9 lbs. per yard to 45 lbs. per yard or more. The type of installation also varies greatly. In some, especially for outdoor systems, wood ties are still used in others, wood ties are replaced by cast-iron plates to which the rails are attached by means of bolts, clips, angle plates, etc. For indoor service, some manufacturers are now supplying solid cast-iron floor plates in which the rails form an integral part of the casting. In selecting the type of equipment, the size of the rails, gage of track, etc., should be predetermined by a careful estimate of the maximum load to be carried, the amount of hauling to be done, number of cars to be used, etc. Frogs, rails, permanent or portable tracks built in sections, crossings, turntables, and rolling stock may, as a rule, now be secured from the same source of manufacture.

MANUFACTURERS (see catalog section):
Easton Car & Construction Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.

285—FUEL OIL.—A product of petroleum or mineral oil. It is unrefined as one of the important items in its use is its low cost and economy, in order to compete with coal and wood. It is the oil as it comes out of the ground with a few of the more volatile compounds like gasoline and kerosene removed. In use it is fed thru special burners that employ air or steam to volatilize it as a spray. It is used extensively in certain sections where the cost is in its favor for firing boilers and kilns. One item that increases its use is the saving in labor as the cost of shoveling coal and ashes is eliminated, and one man can care for more kilns than under a coal fired system. (See also Oil burner.) It is claimed that one man burning with oil can do the same work as 3½ men burning with coal. (See also Fuels, comparison of, in statistical section.)

FUEL OIL ENGINE, see Engine, internal combustion.

286—FUELS, COMPARISON OF, see statistical section.

287—FULLERS' EARTH.—A peculiar kind of porous clay, gray to dark green in color, with a high absorbent power for many substances; due to this property, it is used extensively for filtering and decoloring oils and other liquids. A quantitative chemical analysis indicates that fullers' earth differs chiefly from ordinary clay in its relatively higher percentage of combined water; but a chemical analysis has little value, since a practical test is invariably necessary to prove its value. The mineralogical composition of fullers' earth has not definitely been proven, nor has the cause of its bleaching power been fully explained.

288—FURNACE INSULATION.—A furnace is meant to include any place where fuel is consumed. This refers especially to boiler, dryer and kiln fire boxes of a clay products plant, and since the consumption of fuel always causes heat, insulation of the furnace or fire box will save heat and thereby reduce the consumption of fuel. This insulation can be secured by using any material that resists the passage or radiation of heat, such as cork, magnesia, asbestos, felt, etc. Kieselguhr is also a very good insulating material and can be molded into bricks. Some insulating materials are made into various forms or into bricks and sold under special trade names. (See also Brick insulating; Cement insulating; Insulating materials; Boiler insulation; Heat insulation; Kiln insulation; Insulation, dryer; Cement, high temperature.)

MANUFACTURER (see catalog section):
American Dressler Tunnel Kilns, Inc.
Celite Products Co.

FURNACE, TEST, see Test furnace.

FUSE, BLASTING, see Dynamite and Powder, blasting.

289—FUSE AND FUSE PLUG, SWITCH.—In all electrical installations there is danger of the line being overloaded at some time or other. This overloading may do very serious damage to motors, generators, lights or alternators if no provision is made to protect them. In every good installation, however, they are protected by fuses, which are nothing but short parts of the current that will not carry as great a load as the machines or lights will carry, in fact they are the weakest parts of the current. When the line becomes overloaded to the full carrying ability of the fuses the resistance offered by the fuses heats them to such an extent that they melt, thereby breaking the line of current and protecting the machines and lights from damage. As the cost of replacing these fuses is very small a large saving is made over what would be the cost of repairing one of the machines or lights. Most fuses are enclosed in metal or fiber to remove any danger of fire resulting from the overheating and burning out of a fuse, and many are made to screw into a socket the same as a lamp, so that they are changed quicker and more easily.

290—FUSIBILITY.—A substance is fusible when it may be made to change from the solid to the liquid state by subjecting it to a certain set of conditions. The process of passing from solid to liquid form is termed fusion.

All clays fuse at one temperature or another, the temperature of fusion varying according to (1) the amount of fluxes the clay mass contains; (2) the size of grain of the refractory and non-refractory particles; (3) the homogeneity of the clay mass; (4) the condition of the fire, whether oxidizing or reducing; and (5) the form of chemical combination of the elements contained in the clay.

290A—FUSION.—This term indicates the point at which clay changes from the solid to the liquid state, but complete liquefaction takes place so gradually with most clays that a fusion-range and not a fusion-point is obtained.

Fusion may commence at a temperature of only 900 deg. C., but may be incomplete after the temperature has reached 1,900 deg. C., altho the amount of fused substance has increased all of the time.

Refractories are those clay products, classed as fire clays that resist complete fusion when heated alone, and withstand a high heat without showing any surface fusion.

G

GAGE, DRAFT, see Draft gage and meter.

291—GAGE, PRESSURE.—A pressure gage is an instrument for indicating the amount of pressure which exists in a boiler, pump, pipe, or other container of a gas or liquid. It consists essentially of a graduated dial and a pointer or hand. This pointer is controlled by a spring connected to a plunger. The plunger works in a small pipe which is connected to the container whose pressure is to be indicated. As the pressure changes the plunger moves back and forth and causes a corresponding change in the location of the pointer or hand on the face of the dial.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Hadfield-Penfield Steel Co.

292—GAGE, PRESSURE RECORDING.—Pressure recording gages are especially suited for attachment to the steam line. The record is made on a circular sheet of paper which can be renewed daily. The paper makes a record of the entire 24 hours, but it is especially valuable in keeping track of the night shift.

MANUFACTURER (see catalog section):
Brown Instrument Co.

292—GALVANIZED IRON.—This term generally is meant to indicate the galvanized sheet iron that is generally used for the outside and roof of a building. In the large majority of cases it is corrugated. It makes a very good roof or covering for the outside of a building but is better suited to a storage shed unless there is a wall of some kind to keep the building warm in the winter. On account of the moisture that is contained in clay and the machines, a heavy frost or freeze which could get thru an outside wall or roof of sheet iron would do untold damage, unless some means of heating the building is provided. Even then the money spent for the additional heat would go a long way towards paying for a thicker wall. Galvanized corrugated iron makes a splendid cover, wall and roof for a storage shed. Ordinary iron is affected by the weather and moisture and in order to overcome this tendency the iron is galvanized, that is, a coating of zinc is placed on the surface. Zinc does not oxidize like iron.

294—GANISTER.—The term was first employed to designate a close grained, dark colored sandstone found in carboniferous composition near Sheffield, Eng., and composed approximately of 83% quartz, 13% clay, and 4% moisture. It is now applied to any similar rock consisting chiefly of quartz, yet containing sufficient clay material to act as a bond and not enough fluxing ingredients to lower its refractoriness. Ganister is also the term given to the rock that is used in the manufacture of silica brick. (See also Silica brick.)

GARNET, see Hornblende.

295—GAS BURNER.—Gas burners are attachments for mixing the proper amount of air and gas to produce perfect combustion. In clay products manufacture we are concerned only with natural and producer gas, and will not therefore consider a burner for artificial gas. The more efficient burner for natural gas is a casting thru which the gas flows by means of a pipe. At the end where it burns there is a large flaring cap or casting having holes thru which air is pulled for the combustion on account of the vacuum which the gas creates due to its pressure or flow. This is not very efficient where the pressure is so low that it will not pull in the proper amount of air. Where the pressure is low a burner which will supply air at a low pressure should be used, and is usually built like an oil burner. The air enters in a pipe surrounding the gas pipe and thereby mixes thoroly with the gas. For producer gas the burners generally consist of brick work with the air supply admitted also thru brick work at the point where it is desired for the combustion to take place. In a few cases where it is not desired to have a high heat like in a dryer, the burner often consists of a casting and the air is admitted near the face of the burner. (See also Kiln, continuous, operation of gas-fired.)

MANUFACTURER (see catalog section):
International Clay Machinery Co.

296—GASKET.—A gasket is a flat packing which fits between two flat metallic surfaces, and is designed to prevent the escape of steam, gas or any liquid from pipe joints, valves, pistons, etc. For special conditions, gaskets are made to order to insure proper fit and to prevent waste; for rough usage, they are cut from sheets of such material as canvas woven with asbestos, sheet metal, sheet rubber, asbestos with wire interwoven in it, etc. Each of these materials is particularly suited to certain conditions. Gaskets are used on the hand holes and man holes of any boiler, on pipe unions, pipe couplings, steam chests and water chests of pumps, steam chests of engines, on the connections between castings of internal combustion engines, etc. (See also Asbestos; Packing, sheet; Rubber goods.)

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
U. S. Rubber Co.

GASOLINE LOCOMOTIVES, see Locomotive, gasoline, industrial.

297—GAS PRODUCER.—A gas producer like a retort is an appliance for extracting all of the gases out of coal. In a producer, however, the heat is generated by the solid residue of the coal that is left after the gases are extracted. In a retort the heat for the extraction is supplied from another source. Only enough air is admitted to make perfect combustion for the incandescent bed of coke at the lower part of the gas producer. The heat from this combustion frees all of the gases from the bed of fresh coal on top. These gases are gathered in flues, sometimes refined, and burnt at some other point. When these gases leave the coal the residue is coke, and this coke falls into the lower part of the producer to replace what has been consumed, whenever the ashes resulting from the combustion are removed. Thus the process is continuous, feeding coal at the top, keeping the fire open, and taking the ashes out at the bottom.

The gases which are extracted as described above are led thru flues to some other point where they are mixed with the necessary air and burned with the production of great heat. In clay products manufacture producer gas is used principally in boilers or in kilns. In burning kilns it can be used for either intermittent or continuous kilns. In mixing air with producer gas to insure perfect combustion and highest efficiency the air should be hot if possible. That is one reason gas-fired continuous kilns have been so successful. A steam jet is usually fed beneath the bed of coke to insure combustion and produce sufficient draft.

A gas producer is usually about 12 ft. square or 12 ft. in diameter and about 18 ft. in total height. A producer may be built entirely of brick or consist of a steel shell lined with fire brick. (See also Kiln, continuous, operation of gas-fired; Kiln fire boxes; Boiler; and Kiln, continuous, design and construction, of kiln roof and producer house.)

MANUFACTURER (see catalog section):
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton, Ohio, will gladly furnish Bulletin 126 giving details as to uses of producer gas. Their gas producers have been designed entirely for the clay industry and they undoubtedly have furnished more gas producing equipment to this industry than any other one concern.

GAS PRODUCER, OPERATION OF, see Kiln, continuous, operation of gas-fired.

298—GAS RETORT.—The body for gas retorts consists of about 30 parts clay and 70 parts grog, the whole being tempered in a wet pan to a stiff mass. The mixture is then molded by hand ramming into the shape desired which is often of a cross section which is half flat and half oval. This cross section extends for ten or twelve feet. In the older types the entire length was molded in one piece but lately sectional retorts have been manufactured which are made in lengths of approximately two feet. These sectional retorts are made of fire clay or of the same mixture as silica brick. In burning they are set on end. The pieces are dried slowly, from two to three weeks being the usual time required. The retorts are burned to about the same temperature as other refractories.

GATE, see Valve or gate, storage system.

299.—GATHERER AND HARVESTER, CLAY.—Clay gatherers are attachments mounted on wheels which are used to gather or scrape the thin layer of weathered clay from the top of a deposit. Naturally, a large acreage is necessary, and they are used only by plants which manufacture ware from surface clay. The older type are similar to the large two wheeled scrapers used on ordinary earth moving jobs. The newer type have a large drum mounted between the two wheels and as the gatherer is pulled forward scrapers cut a thin layer off the surface, hoist and dump it into the drum. Horses or mules were formerly used for pulling the gatherer, but lately tractors have been substituted with much success and economy. If the plant using this method of gathering clay wishes to operate during the winter, they gather enough clay during the summer and put it into a storage shed.

300—GEAR DRESSING.—All gears wear more or less, depending on the amount of power transmitted thru them. This wear is sometimes exerted on one gear more than the other by making the first of softer material. Where both gears are made of the same material and even when one is made of a softer material, it is advisable to use a gear dressing which is some plastic and pliable composition to form a coating on the teeth of the gear. This dressing takes up most of the wear due to the friction of the teeth. Hard oil or grease is used at times but it is not good around a clay products plant on account of the large amount of dirt and dust which it can pick up. Dirt and dust packed in a greasy dressing will wear out a gear more than no dressing at all. Many good dressings are prepared which cost very little when the longer life of the gears is considered. Good belt dressing is made of several consistencies, because a high speed gear should have dressing that is a little thicker than a low speed gear, as the centrifugal force will throw away a thin dressing.

301—GEAR, CAST-IRON, STEEL, WOOD.—A gear wheel is a wheel that has teeth on its outer rim or circumference. These teeth mesh with corresponding teeth on another gear wheel and power is transmitted from one wheel to the other, by means of these intermeshed teeth. In some cases the entire gear, i. e., the wheel and the teeth are cast of one piece of cast iron. In other cases the same thing is made of cast steel, or even of manganese steel, depending on the amount of wear encountered. Many gear wheels, however, are made of two or more pieces. Sometimes the teeth and a small portion of the balance of the wheel are cast together in one piece and bolted onto the main part of the wheel. In other cases the outer rim or circumference is provided with dove-tailed grooves, one for each tooth, into which small castings are fitted. This same procedure is followed when it is desired to have wooden teeth instead of metal ones. It is very hard to have two metal gears running in mesh without considerable noise resulting therefrom. It is good practice, therefore, whenever the drive is not so great as to cause large wear on the teeth, to use a set of wooden teeth meshed with a set of iron teeth. There is no noise from this combination.

In many cases it is advisable to have a gear made into halves and fastened together by bolts. This construction makes the renewal of a gear easier. (See also Gear, rawhide.)

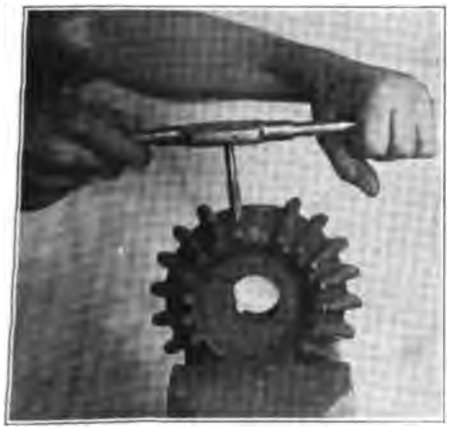
MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Freese, E. M. & Co.
Link-Belt Company.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

GEAR GREASE, see Lubricating oil and grease.

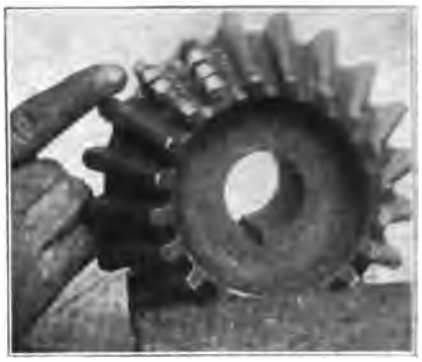
302—GEAR, RAWHIDE.—These are used especially for high speeds, where it is desired to reduce the noise that usually accompanies the operation and meshing of two steel gears at high speed. Usually only one gear is made of rawhide and the other of steel, and this one is usually the pinion. On account of its ability to withstand impact rawhide can be made into gears of the same size as steel if the operation is at a high enough speed. For low speed, rawhide cannot compete with steel on an equal basis of size, due, it is believed to the fact that low speed gears do not have to withstand the impact that high speed gears must withstand. Rawhide gears usually are made up of layers of rawhide which are bound on both ends with a plate of bronze or brass. The entire gear is pressed together and the teeth cut and the hole for the shaft bored at right angles to the layers. The pinions on electric street cars are made of rawhide. If made of steel the resultant noise would be very great. The best use of these gears around a clay products plant is the pinions on motors, especially where the machines are direct connected. Even for this use the speed must be high. For satisfactory service the peripheral velocity of a rawhide gear should be about 1,700 to 2,000 feet per minute.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

303—GEAR TEETH, METHOD OF REPLACING BROKEN.—Quite often a tooth will break out of a gear on account of a weak spot, a sudden increase of load or an impact or knock of one tooth against another. Sometimes the tooth is broken out of some gear that will cause a shutdown or large decrease in production until it is repaired. As this is often a repair job that lasts for several days, a week's production may easily be lost if a new gear must be ordered. The method described here has been used to replace one or more teeth. The place where the old tooth was located is cut off smooth or nearly so, and a hole or holes drilled into the main part of the wheel. The diameter of these holes should be about the same as the thickness of the tooth at the pitch line, a little more than that rather than any less. Into these holes steel pins are threaded, and they should go in tight so that there will be no tendency for them to work out. The number of pins to put in depends on the width of the face of the gear or the width of that part of the tooth which is broken out in case it is only part of the tooth which is to be replaced. The pins are later trimmed by hand chisels, to conform to the sizes of the other teeth. When put in properly, teeth of this kind will last almost as long as the original gear.



Drilling Gear for New Teeth.



New Teeth Finished.

304—GENERATOR AND ALTERNATOR.—A generator or alternator is a machine or device for converting mechanical energy into electrical energy. There are two general classes of electric circuits—alternating current and direct current. A generator delivers direct current; an alternator, alternating current. Direct current always flows in one direction. Alternating current periodically reverses its direction of flow, and runs from 25 to 60 times in each direction per second (hence, the terms often encountered, 110 volts, 60 cycles; 220 volts, 25 cycles, etc.). The usual type of generator or alternator has a shaft mounted on two bearings, and a system of wiring, called the armature, mounted on the shaft between the two bearings. In operation, this shaft is rotated at high speed, and the revolution of the armature near the field coils, which are mounted on the inside of the main casting of the generator or alternator, produces the flow of current. The method of wiring determines whether the current is to be direct or alternating; and again, with the alternating current model, the method of wiring determines whether it is to be single-phase, two-phase or three-phase. As a rule, when a plant generates its own current, a direct current service is advisable; but when current is purchased from a public utility, it is almost always alternating current, since this can be transmitted easier than direct current. A dynamo is the same as a generator. (See also Motor, electric.)

304A—GEOLOGICAL AGES.

General Table of Geologic Divisions.

- Cenozic (Recent Life)
  - Present
  - Pleistocene—Glacial period
  - Pliocene
  - Miocene
  - Oligocene
  - Eocene
- Mesozoic (Middle Life)
  - Transition (Arapahoe and Denver)
  - Upper Cretaceous
    - Western coal beds
  - Lower Cretaceous (Comanche or Shastan)
    - New Jersey Clays—Lignite
  - Jurassic
  - Triassic
    - Sandstones, Conglomerates
- Palezoic (Ancient Life)
  - Permian
    - Limestone, Gypsum, Shales, Coal
  - Coal Measures or Pennsylvanian (Carboniferous)
    - Most all Coal
    - Most Clays and Shales used in Clay Manufacture
  - Subcarboniferous, or Mississippian
    - Waverly (Ohio) Shales, Bedford Limestone, Coal, Poor and Thin
  - Devonian
    - Gas, Oil—Pa., W. Va. and N. Y.
    - Black Shale
  - Silurian
    - Gypsum
    - Niagara Limestone
    - Shales, Sandstone, Iron Ore
  - Ordivician
    - Ohio and Ind. Gas and Oil
    - Limestones
      - Magnesium
      - Trenton
      - Galena
      - [illegible] Hudson River
      - Lead and zinc ores
  - Cambrian
    - Limestones
    - Shales
    - Quartzite
- Great Interval
- Proterozoic (Algonkian) (Earlier Life)
  - Keweenawan
  - Interval
  - Animikian or Penokean (Upper Huronian of some authors)
    - [illegible], Quartzite
  - Interval
  - Huronian
    - Conglomerates
    - Quartz
    - Shales
    - Limestones
- Great Interval
- Archeozoic (Very Ancient)
  - Archean Complex
    - Great Granitoid Series
      - (Intrusive in the main, Laurentian)
    - Great Schist Series
      - (Mona, Kitchi, Lower Keewatin, Coutchiching, Lower Huronian of some authors)
      - Era of first life on earth.
      - Limestones formed from vegetable and animal secretions and silica from silica secretions. Iron oxides and carbonates also formed.

305—GILDING.—A general term in the pottery industry that refers to all gilding processes done by hand. A girl who can put on a narrow line is a gilder, while an artist of the highest type who does elaborate gold work in designs or in paste work is also classed as a gilder.

306—GLAUCONITE.—A common mineral ingredient of some clays, being a hydrous silicate of potash and iron. Its composition is variable with the character of clay and locality in which it is found; it is easily fusible and not a desirable constituent if present in any considerable quantity. Glauconite is found chiefly in the clay marl formations of New Jersey cretaceous deposits, and in the Eocene formations of Maryland and other coastal plain regions.

307—GLAZE.—Glazes are vitreous coatings used to cover clay bodies, either to ornament them or to make them impermeable to water. Their chemical composition is nearly as variable as that of the objects on which they are used, this being the principal means of determining their physical properties, such as hardness, transparency, solubility, etc. Some potters classify glazes according to the relative proportion of acids and bases which they contain; that is, into acid, neutral, and alkaline glazes. In ordinary practice, however, the following terms are more frequently employed:

The term soft glazes designates transparent glazes fusible at a low temperature, generally very plumbiferous, and used to cover thinly certain earthenwares, such as faience.

Enamels are glazes which have a higher melting point than soft glazes; they are usually applied more thickly, and are separated into two classes, opaque enamels and transparent enamels, either of which may contain plain or intricate color designs, or be colorless. Fine earthenware and most pottery objects are decorated with enamels.

Hard glazes are used to cover vitreous pottery or certain kinds of faience made from fine body; they are transparent, hard, applied to form a layer of medium thickness, melt at a high temperature, and nearly always contain alumina or an alkaline earthy base.

In considering glazes from the point of their action on the coloring oxides, they are divided into plumbiferous, boracic and alkaline glazes, according as one or the other of these substances is in a larger proportion and may influence the coloring. (See also Decorative coloring materials.)

308—GLAZE DEFECT, CAUSE OF.—If the glaze is too thin, the ware will have a rough, poor appearance. If the glaze is too hard, it will not flow well nor uniformly over the whole piece, bare spots will remain uncovered, and unless subjected to a very great heat, the ware will have a dull appearance.

If the glaze is too soft, it will run down the piece and collect in drops on the edges, it will liquidize the colors and give the patterns an indefinite, smudgy appearance; but too much fire or too heavy dipping may cause similar results.

Crazing, the worst defect in earthenware, is chiefly due to unequal expansion and contraction of the body and glaze; too low a silicate content is a frequent cause of crazing.

Peeling (sometimes called shivering) may be due to an excess of flint, causing the body to have a greater expansion than the glaze, and thus fracturing the glaze at the edges and corners. Peeling may also be due to short firing in biscuit; to insufficient brushing and cleaning in the biscuit warehouse. In these two latter cases the dust or dirt left on the edges really forms an independent body lying between the body and the glaze, and prevents them from properly uniting.

Pinholes may be caused by hardness of glaze, or glaze with insufficient flowing qualities, or under-glost firing, or badly sponged clay ware, or soft, insufficiently pugged clay.

Blistering may be due to unequal firing or to over-firing.

Dryness may be due to insufficient dipping, hardness of glaze, over-biscuit firing, over-glost firing, placing in insufficiently glazed saggers.

Unevenness may be due to insufficient glost firing, or irregularity in dipping, or infusibility of glaze.

Running may be due to too soft a glaze, over-glost firing, hard biscuit, or overdipping.

Spitting out—which means that the glaze becomes rough and full of little black specks—is generally attributed to the ware being damp. Old ware, which has been some time in the warehouse, is more liable to this defect than ware from the ovens.

309—GLAZE GRINDING MACHINES.—These are types of ball mills in which the mill is lined with pieces of stoneware, and flint balls are used entirely. In this way the material which is being ground does not come into contact with any iron and therefore the glazing material cannot gather any iron to spoil the glaze.

MANUFACTURERS (see catalog section):
Bonnot Co.
Mueller Machine Co., Inc.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of grinders for reducing salt and other glazing materials.

310—GLAZING MATERIAL, HOW TO PREPARE.—Glazing materials are prepared in the sliphouse department, the ingredients varying according to the special purpose for which the glaze is to be used (see Decorative coloring materials). All glazes, however, go thru the same general process. In preparing a raw glaze, the materials are thrown in a burrstone or ball mill and ground under water. If the glaze is to be a fritted glaze, the materials, including the crushed frit, are mixed in the same manner and very thoroly ground.

Some English potteries have frit kilns. An average size kiln, having an output of about 40 tons every two weeks, is about 15½ ft. long, 4 ft. wide, and 4 ft. high. The part containing the frit ingredients is 11 ft. long. After having been fired for 3¾ to 4 hours, 600 lbs. of fluid frit flow into a shallow iron tank containing three inches of cold water. Upon contact with the water, the frit soon solidifies. The shattered glass fragments are piled in a bin convenient to the glaze pans or the glaze mills. The frit kiln is in use for two weeks; the third week it must be rebuilt and repaired.

In United States potteries the frit ingredients are placed in saggers and fired in regular kilns. Grinding cylinders 7 ft. in diameter and pulverizing cylinders 5½ ft. in diameter, or glaze pans made of sheet metal and paved with stone, are used in reducing the glaze materials to the desired consistency. After passing thru the sifter lawn and magnets the glaze flows to a receiving ark, from which it is pumped to the dipping room. Great care is exercised in preparing glaze, since a poorly prepared glaze will cause much damage to the ware. (See also Frit.)

GLOST KILN, see Kiln, biscuit and glost.

311—GLOVES.—Gloves are worn in clay products plants for several reasons. Many shales and clays are of such a nature that if touched while in the wet state, any ware will show this mark when burnt. Gloves are often worn to prevent this discoloration. Again repressed brick have oil on every surface and at times they are hard to pick up. Gloves worn by the men make this work easier and prevent dropping the brick onto the car. In the manufacture of silica brick it is necessary to wear rubber gloves to prevent the lime injuring the hands. In handling burned ware of any kind, gloves, usually made of leather, and called "hand leathers" are most serviceable. Some of these cover and protect only the palm of the hand and fingers, thus providing thoro ventilation, and adding to the ease with which the ware can be handled. (See also Hand leathers.)

312—GOVERNOR, ENGINE AND PUMP.—A governor is an attachment or device for controlling the speed or pressure exerted by an engine or pump. Engine speed is controlled by some form of centrifugal motion. In ordinary slide valve and corliss engines this governor is usually in the form of two iron balls, which swing outward from the central spindle more and more as the speed increases and swing closer to the spindle as the speed decreases. The balls are made to revolve around the central spindle. This centrifugal motion is transferred by means of levers and rods to a throttle valve which controls the amount of steam going into the cylinder. In a corliss engine this motion controls the cut-off of the valves instead of the throttle valve. In an automatic engine the centrifugal motion is exerted on two balls which are mounted on one of the flywheels, and this motion is transferred to control the cut-off of the eccentric. A pump governor is made to control the pressure exerted on the water end of a pump. The pressure of the water cylinder is exerted on a disc or plunger, the movement of which controls the amount of steam reaching the cylinder, so that if the pressure goes above a certain amount the steam is shut off entirely. Engine governors are necessary to prevent racing of an engine and consequent danger of damage, when the load is reduced, and pump governors are necessary to prevent the pressure on a pipe line rising so high that it will affect and injure the pipe joints.

GRAM (also spelled gramme), see Metric system.

313 — GRANULATOR. — Granulators are used for preparing plastic clay and feeding it to the crushing rolls in a properly prepared condition and at a uniform and constant rate of speed. The object is to reduce the labor of feeding clay to the crusher.

A granulator consists basically of two I-beam supports upon which is mounted a long mixing chamber, semi-cylindrical in shape, and open at one end to permit discharge of the material. At the other end is located the belt-driven pulley, equipped with a friction clutch, and a large cast-iron housing which contains a driving gear mechanism which, in turn, transmits power to a long steel shaft, equipped with knives, that extends thruout the length of the tank. The knives are adjustable as to pitch, so that when the shaft revolves they not only cut, mix and granulate the material, but at the same time discharge it from the mouth of the trough or tank at any desired speed, much the same as a screw conveyor would do.

As the granulating process and rate of discharge are required to be rather constant, only one lever is generally employed to control the operation; this lever connects with the friction clutch of the belt-driven pulley and is used to start or stop the machine at will.

Granulators are furnished in a variety of designs, each manufacturer attributing to his machine many distinctive features in construction and operation. The capacities of the various sizes and types range from approximately 5,000 to 15,000 standard building brick per hour.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.

314 — GRAPHITE.—Graphite is an impalpable form of carbon. It is made in several different sizes of powder and flake. It is an excellent lubricant, in fact the only lubricant outside of oils and greases. Many of the prepared greases, especially those sold for auto truck transmission and differential cases, have graphite in them. It is very good practice to spread graphite on boiler gaskets before putting them into place as they do not stick when being taken out. The same is true of gaskets in pipe unions, pumps, etc. Graphite is far better than oil or grease as packing in the roller bearing boxes of dryer cars. It will be unaffected by the heat and not gather dust and dirt as do oils and greases. Many of the packings for pistons, rods, stems, etc., are permeated with graphite when manufactured. Graphite is also serviceable if put into a boiler to prevent the scale from sticking to the tubes and shell. The scale can, therefore, be removed more easily thru the blow-off. (See also Graphite crucibles.)

315—GRAPHITE CRUCIBLES.—These crucibles are used for the melting of alloys and metals, and fusion work in electric furnaces. The raw materials consist of some good pot clays and a pure variety of graphite. Ceylon graphite is best because of its leafy or foliage structure and great compactness. Generally about 75 parts clay, 25 parts quartz, and from 80 to 100 parts of graphite are used. (See also Crucible manufacture.)

316—GRATE AND GRATE BAR.—Except in comparatively few cases, all hand-fired fire boxes of kilns, dryers and boilers use grates on which the fire rests. The grates are composed of a series of bars spaced apart so as to permit the air necessary for combustion to pass thru the openings to the fire above; the arrangement also facilitates the removal of ashes. There are two general types of grates, horizontal and inclined. The former is the type usually used under boilers and in hand-fired dryers. Both types are used in kilns, however, and it is hard to determine which is the better, since the only argument in favor of either type is often the preference of the man in charge. Some of the horizontal type are mounted on a framework, so that when it is desired to dump them it can be done easily. A cleaner fire results in a very short time. (See also the two items under Stoker.)

MANUFACTURERS (see catalog section):
Canton Grate Co.
Eagle Iron Works
Hadfield-Penfield Steel Co.
Toronto Foundry & Machine Co.

GRAVITY CARRIERS, see Carriers, gravity.

GREASE, see Lubricating oil and grease.

317—GREASE CUP.—These attachments are intended to provide adequate and economical lubrication for shaft bearings. They consist of cast iron or brass, and one part screws over the other. The outside part contains a storage of grease, and the part which screws into the bearing has a hole in it to allow the grease to get to the bearing. The grease is forced into the bearing either by turning the larger part of the cup by hand or by a spring which exerts a uniform pressure against a plunger. The pressure of this spring can be regulated. Another type of grease cup has a pin which is long enough to reach from the shaft that is to be lubricated to the upper part of the cup which contains the storage of grease. The revolution of the shaft jars this pin slightly and its friction in the grease causes the grease to flow down the pin to the bearing. The latter type uses a better grade and a smaller quantity of grease than the former.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Link-Belt Company.
Webster Mfg. Co.

318—GRINDING.—This is the process of pulverizing or grinding clays or glazes so that they will be homogeneous and mix more readily with water. The several types of Crushers, Dry pans, Ball mills, Pulverizers, Wet pans, Chaser mills, Kent mills, and Disintegrators are all described under their several headings. Any impurities can also be found and removed during grinding or reduced to such small particles that all or most of the danger is obviated.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Eagle Iron Works.
Mueller Machine Co., Inc.
Stevenson Co.
Williams Patent Crusher & Pulverizer Co.

319—GRINDING WHEELS.—A grinding wheel is a wheel made of a high abrasive for cutting and dressing metal and tools. It is driven at high speed which adds to its power in cutting. Grinding wheels are generally made of abrasives which are fused together by burning, the same as other clay products, but at a very high heat. They are usually mounted on a standard on the same arbor or shaft, in pairs driven by a belt about two inches wide. There is also a type of portable grinder which is practically the same except that it is driven by an electric motor. This is very convenient as many times the work can be done in the plant quicker than it can be removed to the machine shop and finished there. At times it is good practice to mount the portable grinder on the shaper or planer in place of the usual cutting tool, as the depth of the cut can be gaged exactly, which is not possible where the operator holds the work up to the ordinary grinding wheel. Grinding wheels vary in the size of the grain of the abrasive, in hardness, in diameter, and in the width of the face. They will give the best results only when full consideration is given these four items in selecting a wheel for any work.

All grinding wheels generate heat in their work and care must be taken that the metal will not heat sufficiently to change its temper. Water or a blast of air affords a good chilling effect when the work is liable to become overheated.

MANUFACTURERS (see catalog section):
Mueller Machine Co., Inc.
New York Belting & Packing Co.

320—GROG.—Generally, grog is composed of such refractory materials as pulverized pottery, crushed fire brick, crushed quartz or quartzite, crushed burned ware, crushed clinkers from kiln or boiler furnaces, or of sand. It is used largely to reduce lamination in plastic clays and also plays an important part in drying.

Grog reduces lamination because of its granular character. It acts as a binder, as a lot of teeth, or, as it were, as a drag to prevent the plastic mass slipping on itself. To serve this purpose, grog is made relatively coarse. Its effect on drying is (1) to increase the pore space in the clay mass so water will flow more rapidly to the surface; (2) to reduce shrinkage, thus reducing the degree of strains; (3) it increases the strength of the clay by its binding action and thus enables the clay to withstand more strain.

MANUFACTURERS OF GRINDERS (see catalog section):
Mueller Machine Co., Inc.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of crushers for reducing old brick and tile.

321—GROUND LAYING.—Potters' term; refers to a method of applying solid colors either in broad bands or over the entire surface of the ware. A particular kind of oil known as ground-laying oil is applied to the ware. This is very carefully and evenly bossed by a fine chamois-skin boss similar to a powder puff. The finely powdered color is then dusted on the ware, the color adhering to only the parts to which the oil was applied. The process is not now generally used on account of its deleterious effects to the operator, who is apt to inhale more or less of the powdered color.

322—GROUND LAYING, WET-PROCESS.—Wet-process ground laying is intended to produce the effect of the dry process, but the results are not as rich nor effective; the method consists of mixing the oil with the color, applying it with a brush, and bossing it in the same manner as described under Ground laying.

323—GUARD, LAMP.—An electric light globe is very fragile and this is especially true in and around the plant, machinery and kilns of a clay products plant. Guards to prevent this heavy breakage are made of wire interwoven to form a basket around the globe and fasten onto the socket. If desired these guards can be locked in place so that no one can remove or appropriate them without authority. Extension lights that are used in the inaccessible places around machinery, etc., should always be equipped with guards, and if desired these guards can be equipped with handles for easier movement and with hooks to hang in any position.

GUIDE ROLLER, see Roller, guide.

324—GYPSUM.—Chemically known as $CaSO_4$, $2H_2O = CaO$ 32.6%, SO_3 46.5%, H_2O 20.9%. This mineral is probably not widely distributed in clays, altho some deposits contain large quantities of it. Gypsum may occur in a finely divided condition, or in the form of crystals, plates, or fibrous masses of selenite. When it is found in pieces of microscopic size, it is easily identified by its softness, pearly lustre, and transparency. At a temperature of 121 deg. C. (250 deg. F.), gypsum loses its water of combination, and at still higher temperatures the sulphuric acid may be disposed of.

MANUFACTURER OF GRINDERS (see catalog section):
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of crushers and pulverizers for the reduction of gypsum rock.

GYRATORY CRUSHER, see Crusher, gyratory.

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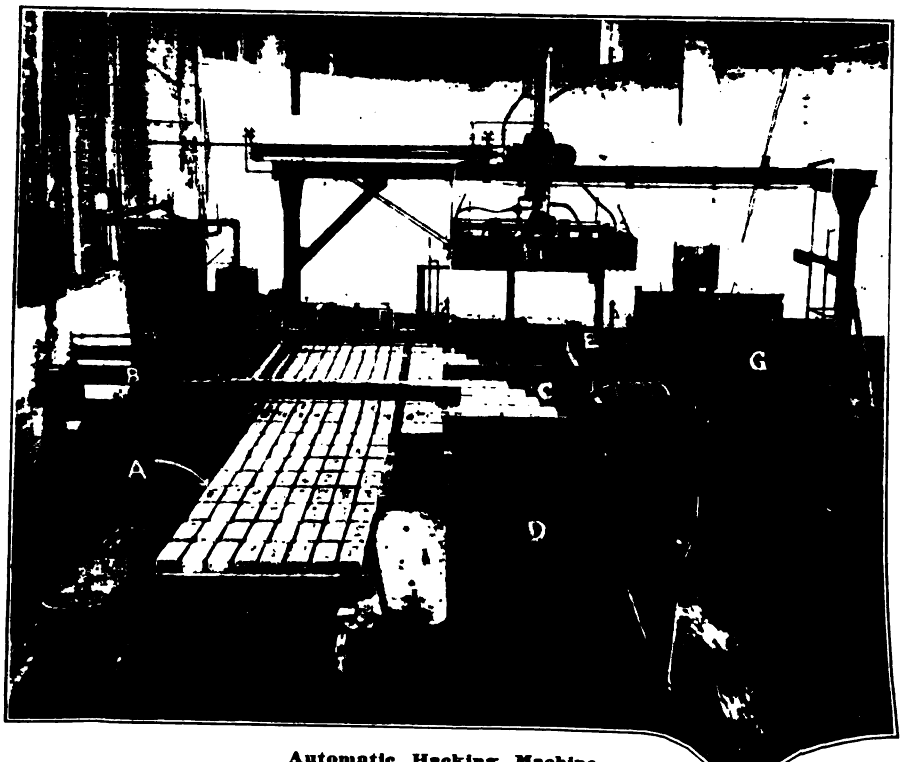


Automatic Hacking Machine.

324A—HACKING MACHINE.—This is a patented device which has been developed for the purpose of mechanically hacking brick after they leave the dryer. The pallets holding the brick are carried on conveyors (as shown at A in the illustration), from the dryer to the hacking machine. This is composed of a separating table and an assembling table. When the pallets loaded with brick arrive opposite the separating table a pusher (B) automatically pushes the brick onto the separating table (C) at which point gravity places them on edge on an endless belt (D). This belt carries the brick to the assembling table (E) exactly spaced. A mechanical lifter (F) then picks up this assembled course of 192 brick from the table and automatically places them on the cars (G). Nine of these courses constitute a car load of 1,664 brick and they are placed on the cars in regular formation. These cars of brick are then transferred from the hacking machine to the kiln where the unit consisting of one-half the car load or 832 brick is picked up by the setting machine and placed in position for burning in the kiln. This hacking machine is automatic in every respect and will do the work of 25 to 30 men.

This machine when used with the equipment described under the items headed Setting machine, Loading machine and Soft mud brick automatic dumping attachment, makes a brick plant thoroly mechanical and automatic. The brick are not touched by hand at any point of the process. The patents on this machine are owned and controlled by The American Equipment Company, 1619 Conway Building, Chicago, Illinois.

MANUFACTURER (see catalog section):
American Equipment Co.

325—HALLOYSITE.—A massive, clay-like or earthy mineral with a conchoidal fracture and showing little or no plasticity; hardness 1-2; specific gravity 2.0-2.20; luster somewhat pearly to waxy or dull; color, white, grayish, greenish, yellowish, and reddish; translucent to opaque, sometimes becoming translucent or even transparent in water, with an increase of 20% in weight. It is a hydrous silicate of alumina like kaolinite, but amorphous and containing more water; according to Le Chatelier it is probably composed of 43.5% silica, 36.9% alumina, and 19.6% water. The composition of various deposits found in this country and abroad vary greatly.

326—HAND LEATHERS.—In handling burned ware made of clay, and especially brick, drain tile, hollow tile, fire brick, etc., the workmen must wear some protection on their hands. Pieces of old shoes, cement sacks, belting that has been used and then taken out, and almost anything has been brought into play for this purpose. Often the article used was taken from the store room if possible. Lately several types of hand leathers, manufactured for use of the men who handle burned ware have been put on the market, at a very low price. One of the principal troubles with the old make-shift home-made affair was that at times it became too cumbersome to handle the ware properly and the man would as a result drop or pitch the ware too hard and thereby injure it. Manufactured hand leathers are made to protect the palm of the hand and fingers only. This allows a maximum of ventilation, which is very necessary and prevents chafing of the hands. They are fastened by bands or straps around the wrist and back of the hand. The use of these hand leathers is growing very fast as they are proving very satisfactory to the workmen and to the plant owners. They last longer than the old type. (See Gloves; Footwear.)

327—HANDLING.—Potters' term for the process of making and attaching handles to articles not completely finished by the makers. For example, cups are first made, in United States, by a cup jiggerman, and by a cup maker in England. In this country a larger proportion of cups are then finished on the turning lathe by a turner; in England they are finished by cup spongers. The handler then finishes and places the handles on them. The handles are made by helpers in plaster of Paris molds, several being made simultaneously. They are then trimmed and stuck to the ware with liquid slip, sometimes containing a small amount of gum arabic. The handler and finisher of large articles makes his own handles and is known as a sticker-up, which is a distinct occupation from that of the handler of cups and small ware.

328—HAND PAINTING.—This is the process of decorating or painting chinaware or pottery by hand. It is ordinarily an overglaze decoration and finished by firing in a special kiln called a china kiln. (See also Pottery decoration; Decoration, overglaze.)

329—HAND-WEDGING.—A potter's term. The operation consists of taking a large lump of pugged clay, cutting it in two, forcibly bringing the two parts together, then kneading the mass to render it perfectly homogeneous and free from air bubbles. The operation is repeated several times. (See also Wedging-table.)

330—HARDNESS TEST.—This consists of applying any one of the following tests to a piece of clay or clay ware. (a) Scratching surface with a piece of steel; sometimes used in testing terra cotta. (b) Grinding test; done on a wheel or grindstone. (c) Gay's test; done on a revolving table; weight lost during a certain time is measured. (d) Barnell's test, by means of which a weight is dropped on a sphere from a given height. (e) Rebound test; drop a weight on a piece of clay and note rebound. (f) Sand blast test; sand, under a certain pressure of air, is blown against the area for a given time; this method is sometimes used for paving brick.

HARVESTER, CLAY, see Gatherer and harvester, clay.

331—HEATER, FEEDWATER.—A feedwater heater is a piece of equipment or appliance for the boiler room, in which the water that is to be fed into the boiler is preheated almost to the boiling point. This preheating is accomplished by piping exhaust steam into the heater and allowing the water to absorb the heat from the steam. A large percentage of the scale and sediment in the water can be removed in a feedwater heater.

MANUFACTURERS (see catalog section):
Canton Grate Co.

332—HEAT INSULATION.—Heat results from the combustion of fuel, and using any material to retard the radiation of heat is insulation. Insulation therefore reduces the amount of fuel used and this lowers the fuel cost. One example of insulation is the practice of building the walls of a dryer, kiln or boiler setting as thick as practical. The insulation of brickwork, however, can be increased by the use of other materials, which are poorer conductors of heat, such as magnesia, cork, asbestos, felt, kieselguhr, etc. Hollow tile are very good for insulation where the pressure is not great enough to crush them. Air leakage thru the joints and between the courses of brickwork is another source of lost heat, and affords another reason for using insulating materials. (See also Brick, insulating; Cement, insulating; Insulating materials; Boiler insulation; Furnace insulation; Kiln insulation; Insulation, dryer; Cement, high temperature; Kieselguhr; Mangle, dipper's, and Stoveroom, automatic.)

MANUFACTURER (see catalog section):
Celite Products Co.

HEAVY SPAR, a term used for barium sulphate, see Barytes.

332A—HELICAL GEAR.—In a helical or herringbone gear the gear teeth are not parallel with the shaft on which the gear is mounted as is the case with plain spur gears.

The most improved form of these gears is one in which the tooth is in the form of a V on the face of the gear. The two legs of the V shaped gear make an angle larger than a right angle at the point of the V which is generally pointed up rather than downward.

These gears do not make as much noise, and wear longer than spur gears because more than one tooth is always in mesh. Another advantage is that each gear holds the other in place and there is no tendency to exert a lateral motion to the shafts, or for the gears to slide.

333—HEMATITE.—The oxide of iron (Fe_2O_3), red in color, sometimes found in clays. On exposure to air or moisture it readily changes to limonite.

HERRINGBONE GEAR, see Helical gear.

HIGH TEMPERATURE CEMENT, see Cement, high temperature.

334—HIGHWAY IMPROVEMENTS, RECORD OF.—The first stone roads are thought to have been built as early as 1,000 to 2,000 B. C. Streets of ancient Rome are believed to have been paved in the fourth or fifth century after the city was founded. The Appian Way was begun in 312 B. C.; it was 14 to 18 ft. wide and still exists in part. Paved streets were first laid in Paris about 1184, when that city had a population of less than 200,000. Strand street, London, was directed to be paved by an act of parliament in the 14th century; it is claimed, however, that the first regular street paving was done in 1533 when London had a population of about 150,000. In the days when the first paved streets were put down in London and Paris, streets were not used for wheeled traffic, the merchandise being transported by pack animals. As late as the 17th century, people were carried about the cities in chairs, and trains of pack horses were the freight carriers. According to one highway engineering authority, the oldest pavements that have been seen by people of the present day were those disclosed by excavations at Pompeii; but these highways were undoubtedly intended for pedestrian, not vehicle, traffic. The mileage of highways in United States exceeds 2,500,000 miles; of this amount, a little more than 10% is classed as improved.

335—HOIST.—Hoists are used for hoisting or hauling a car of clay from the pit, or, in the case of a mine, to hoist the cage on which there is a car of clay. There are a few special cases where a hoist is advantageous, such as in pulling cars of overburden over a hump so that they can coast downhill to the spoil bank, etc. Hoists consist of one or two drums onto which the cable is wound as the drum revolves. The hoist can be driven by a steam engine, motor, or gasoline engine. Brakes are always provided so that the cars or cages can be let down again without injury or danger, and no more cable allowed to run off of the drum than necessary. In some cases there is provision for letting one car or cage down while the other is being hoisted. This, of course, saves time. (See also Drum, winding; and Crane.)

MANUFACTURERS (see catalog section):
Eagle Iron Works.
Freese, E. M. & Co.
Green, L. P.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Steele, J. C. & Sons.
Weller Manufacturing Co.

HANGER, see Shafting, hanger for.

336—HOLLOW BLOCK AND BRICK.—Hollow block are usually 12 inches long overall, and the other dimensions may vary from three by six or four by five to 12 by 16 inches. These may also be irregular in shape for special purposes. They are usually more or less hollow and may have one or a number of webs to strengthen the block, the webs wherever they cross forming cells as they are termed. Hollow blocks are made on a stiff-mud machine and can be either smooth, corrugated or ornamental on the surface. They are used for exterior walls or foundations principally, and a stucco plaster can be put on. Terra cotta lumber is a form of hollow ware which is so porous that nails can be driven into it. This is made by putting saw dust into the clay before burning. Hollow bricks are the same size as ordinary brick, but have one or more holes in them so that they do not weigh as much. They are used in any backing up work. Both hollow blocks and hollow brick are adapted to be used in any of the construction work around a clay products plant, and especially wherever it is desired to retain heat and the pressure would not be great enough to break them. (See also Die, factors of operation.)

337—HOLLOW TILE MACHINERY.—Hollow tile are made same as brick except as to method of molding and are almost universally made on horizontal auger machines. The manufacture of hollow tile on a steam press does not offer any greater problem than the manufacture of any other shape. With an auger machine, however, of either the vertical or horizontal type, hollow tile requires special construction and lubrication. The manufacture of drain tile does not offer as great a problem, because the cross section is concentric, and naturally the flow of clay is nearly uniform. Likewise, in the manufacture of brick the column of clay is solid and the only difficulty is to design the machine to insure as uniform a flow of clay as possible. In the manufacture of hollow tile, however, it is impossible to lubricate all of the surfaces of the cores, and moreover it is difficult to have the same flow of clay at the centre of the die as at the corners of the die. (See also Die, factors of operation.)

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

International Clay Machinery Company, Dayton, Ohio, build a complete line of hollow tile machinery and are prepared to furnish estimates on either complete plants or on individual machines. See our pages in catalog section.

HOLLOW WARE FOR STRUCTURAL WORK, see Fireproofing, Hollow block and brick, and Terra cotta lumber.

338—HOLLOW WARE PRESSING, PROCESSES OF.—The term refers in the pottery industry to the hand process of making such articles as soup tureens, cover dishes, jugs, etc., by pressing clay on or into molds in such a manner that it receives the exact form of the mold, the pieces when extracted being an exact replica of the mold.

In pressing a jug, for example, the mold may be in three sections, two sides and bottom. Bats of clay are prepared and placed in each section, care being taken to keep smooth the surface that is applied to the mold. Pressure is then applied to the clay, either by moderately flexible pieces of leather, a piece of double flannel, or by daubing with a soft sponge until the clay conforms with every indentation of the mold. The waste or excess clay is removed, and along each edge of one section a thin layer of clay is applied. The two side sections are then fixed together and firmly held by a piece of rope or leather, pressure being applied to the roll, either by the finger or a piece of leather, in order to join them together. The side sections are then placed on the bottom mold, on the edge of which has been placed a roll of clay. This roll is pressed into a joint between the sides and bottom, and thus the three sections are made one. The inside is leveled and smoothed by means of a sponge or leather, and a finish given to it by carefully applying the edge of a smooth piece of India rubber. The mold is then placed in the drying room and the clay article allowed to dry until it begins to shrink from the mold surface, at which time it is taken from the mold and the rough edges from the top and seams are removed with a knife, a smooth surface being given all parts by means of a damp sponge. The ware is then ready for applying the handle. The handle is made in a mold of two sections; the clay is placed in one section, the other section is placed on top, and the two parts are squeezed together to form the handle, much as a waffle-iron forms a waffle. After pressing, the handle is dried to the same degree as the jug, and the rough edges smoothed in the same manner. The parts to come in contact with the jug are then cut into proper shape, the surfaces are moistened with water or slip, pressure is applied, and the handle becomes part of the jug. The slip used may be either body slip or ball slip, or a mixture of the two. Care must be taken to avoid over drying, since if the jug is allowed to become too dry and the handle is in a soft condition, the difference in contraction during firing and drying may cause cracking; if the handle is too dry and the jug soft, the same fault will arise. If the jug is round and the handle too large, the jug top may be pulled out of shape by the handle. Care is also taken, when the handle is applied, to remove all excess slip or water, either with a sponge or camel's hair pencil, otherwise cracking will result because the point of contact is unduly softened, thus causing a difference in contraction.

The principal faults in hollow ware pressing are varying thicknesses, cracking at seams due to insufficient pressure or the inclusion of water in the joints during welding, irregular surfaces due to the inequality of pressure, and hollow feet due to bad welding. The seams or joints of pressed ware are always raised after firing, which is due to the fact that greater pressure is applied at these joints during the welding of the sections, and there is consequently less contraction.

MANUFACTURER OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.

HOOKS AND RIVETS, BELT, see Belt hooks and rivets.

HOPPER, see Storage bin.

339—HORNBLENDE AND GARNET.—Both silicate minerals of complex composition, and probably occur in considerable quantities in numerous impure clays, but their grains are rarely over microscopic size. Both fuse easily, and weather readily because they contain iron oxide; this is what causes them also to impart a deep red color to clays formed from rocks in which they are a prominent constituent.

340—HOSE, METAL.—This term refers to the outside covering of the hose. Ordinary hose has either rubber or canvas on the outside. Either of these coverings can easily be affected by heat, oil, steam, etc., and also by kinks. Metal hose is made to overcome these troubles. The outside of a metal hose consists of a spiral piece of metal, which interlocks at every lap. This interlocking is made flexible, so that the hose, altho stiff, can be bent around corners, thru holes, etc. Metal hose is a great saving in many cases; for instance, when using a steam or water turbine flue cleaner, for compressed air or vacuum of any kind.

341—HOSE, RUBBER.—A hose is a flexible pipe. It must be liquid proof, and therefore rubber becomes a necessary part of practically every hose. The foundation of every hose is canvas or similar fabric. Rubber is used at times on the outside, usually on the inside and always appears in some place to fill all of the pores of the canvas. Hose which is used for suction or for creating a vacuum must be made extra strong to withstand the atmospheric pressure. (See also Hose, metal, and Hose, steam.)

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
New York Belting & Packing Co.
U. S. Rubber Co.

342—HOSE, STEAM.—This is a form of rubber hose made by special process for transmitting steam. Since steam is used to vulcanize rubber, the continued contact of steam and rubber will deteriorate the hose in a very short time, and for this reason special care is used in its manufacture, to overcome this trouble, as far as possible. Steam hose must also be made strong enough to withstand considerable pressure. In clay plants, steam hose is used to transmit steam from a pipe to the die of the auger machine, to the dies of the dry press, to the dies of a repress, etc. Many boiler tube cleaners are operated by steam, and as these must be moved back and forth in the boiler tubes, steam hose is used to provide the flexible connection between steam pipe and cleaner. Metal hose is often used for the latter purpose. (See Hose, metal.)

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
New York Belting & Packing Co.
U. S. Rubber Co.

HOT FLOOR, see Dryer, floor.

342A — HOUSING, GEAR. — A gear housing is used whenever it is desired to prevent any chance of accident, or to prevent dust and dirt from gathering on the teeth and thereby wearing them too fast.

At times a gear housing is made tight and used to hold oil for lubricating the teeth. In this case the lower gear must extend partly into the oil.

The latter is the use made of a gear housing in connection with silent chain drives. This lubrication between the chain and the gear adds very materially to the life of each.

MANUFACTURER (see catalog section):
Link-Belt Company.

343—HYDRAULIC PRESS.—A form of dry press formerly used for the manufacture of face and building brick to a great extent, and even used today in some plants. The pressure is exerted according to the well known laws of hydraulics, namely, that a small piston exerting a certain force on water or other liquid can greatly enlarge that force by having another piston of larger diameter inside of a cylinder connected with the small cylinder. The pressure of a hydraulic press is considerably larger than that of a dry press machine, and is about 60 tons on each brick.

344—HYGROMETER.—A hygrometer is an instrument for ascertaining the amount or percentage of moisture held by the air in a certain place. This is done by means of a "wet" and "dry" bulb thermometer. The dry bulb part is the same as the ordinary thermometer and indicates heat. The wet bulb part is constructed the same as an ordinary thermometer, but the bulb is surrounded by a porous cloth which has one end in a small container holding water. If the air to be tested is not fully saturated with water, the water will evaporate from the cloth which surrounds the wet bulb, thereby causing a lower heat at the bulb, and consequently a lower indicated temperature on the scale. Tables are provided which show the amount of moisture in the air, based on the difference in temperature between the dry and wet bulbs. Of course the amount of moisture already in the air and the temperature govern the rate of evaporation. Hygrometers are suited very especially to drying conditions of clay ware, whether the drying is done in a room, dryer, tunnel, storeroom or mangle. The proper amount and rate of heat for each kind of ware and each clay can be regulated or changed for the best results, when the information obtained by the use of a hygrometer is available. Many kiln losses, if traced back, can be found to be caused by irregular, fast or improper drying, and many of them can be eradicated by the use of a hygrometer. (See also Dryers, and Thermometers.)

MANUFACTURER (see catalog section):
Brown Instrument Co.

344A—HYGROSTAT.—An instrument for regulating the moisture in a dryer or other room. It is a hydrometer which works automatically. (See also Hydrometer and Dryer, humidity.)

I

344B—IDEAL WALL.—This is a type of wall that is to a certain extent new in this country. But there are houses built of this style of construction that have been in existence for years and one house has been found in Sweden built of this construction over 100 years old.

The brick are laid on edge as shown in the illustration. Every four inches a full length brick is laid that ties the outer wall to the inner and prevents the development of any weakness.

This type of wall requires only nine brick to a square foot of wall for the same thickness that requires thirteen if built of solid brick. A four inch dead air space extends thruout the wall from one end to the other and from bottom to top. This acts as an insulation and also prevents any moisture from traveling thru the wall.

The adoption of this type of wall will add immensely to the demand for common brick and help the other branches of the industry manufacturing construction materials.

(See illustration on page 60.)

345—ILMENITE.—A mineral ($TiFe_2O_3$); most likely to occur, if it does occur, in clays which have been taken from soda-rich and basic eruptive rocks.

346—INCOME.—The amount of money received by an individual or corporation, in a certain space of time. There are several ways of considering income. In corporation accounting, gross income is meant to include all money received whether from sales, investments or other sources. Net income is the same amount minus all expenses for labor, coal, repairs and supplies necessary to operate the business. Net income is later reduced by an allowance for depreciation and obsolescence and the remaining amount is the profit for the period. Gross profit and net income are really the same, and the amount remaining after the deduction for depreciation and obsolescence is net profit.

347—INCOME TAX.—This is a sum collected from individuals, partnerships and corporations as a tax payable to the federal government and in some states to the state governments, based on the amount of income over a certain amount. The state income taxes are based on the federal rates but they vary considerably from one state to another. Space will not permit us to go into any detail about the amounts due on income taxes. Practically every case has some feature that is different from the rest, and the advice and counsel of one who is experienced in these matters will save more than the fee charged. Income tax laws and the exemptions allowed are complicated to figure in the case of a partnership or corporation.

Eight Inch Ideal Wall.

Many companies are having appraisals made of their properties and especially of their holdings Jan. 1, 1913, in order to establish a new basis for determining income taxes. Appraisals have enabled some companies to obtain rebates on taxes already paid that amounted to many times the cost of the appraisal.

348—INCRUSTATION, POTTERY.—This consists in molding simultaneously two bodies forming two layers placed above each other, the thinner, placed on the apparent facing, constituting the slip, and the thicker, inside, serving to give to the piece of pottery the thickness necessary for its solidity, representing the body proper. According to the process of making employed, incrustation can be done in different ways.

In hand molding, the layer of slip is placed in the mold in such a way that it fills all the parts to be in relief, the body then is added, and forced to adhere to the slip by judicious beating and pressure.

In pressing, a rough outline is first made by means of two layers of body placed parallel above each other; or when the making is done with dry body, a certain quantity of powdered engobe is placed in the mold, and the filling is completed with powdered body. In both cases the pressure determines the adhesion of the body and its slip.

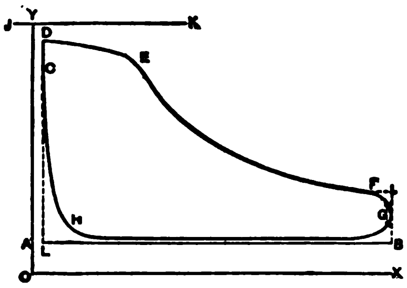
349—INDIANAITE.—A whitish residual clay found in Lawrence County, Ind., which is placed under halloysite by Dana (see System of Mineralogy, 688, 1892), and called allophane in the state report (see Ind. Geol. Surv., 29th Ann. Rept.).

INDICATOR, MOISTURE, see Hygrometer.

350—INDICATOR, SPEED.—A device for showing the speed at which a shaft is operating or revolving. It consists of a spindle of small diameter, one end of which is finished as a cone of about one-quarter of an inch diameter. A handle is provided by means of which the cone end of the spindle is held against the end of a shaft whose speed is to be indicated. The spindle drives a dial by means of a worm gear. This dial shows the number of revolutions of the shaft for any length of time that the indicator is held in contact with the shaft. The end of the shaft must have a countersunk cone to correspond to the cone end of the spindle of the indicator. One end of a shaft usually has a cone of this type cut into it when the shaft is being turned up in the lathe.

MANUFACTURER (see catalog section):
Brown Instrument Co.

351—INDICATOR, STEAM-ENGINE.—A steam-engine indicator is an attachment or appliance to show graphically the work that is being performed inside of the cylinder. A pencil traces a line on a sheet of paper. The pencil has two forces working on it, the first representing the length of the piston stroke, and the second representing the pressure on one side of the piston at every point of the stroke. Only one side of the piston or end of the cylinder can be indicated at a time. By means of an indicator it can be easily determined whether or not a steam engine is working efficiently, the amount of power being developed, etc. The best way to set a valve is by comparing the action of the valve with an indicator diagram.



Steam Engine Indicator Diagram.

INFUSORIAL EARTH, see Kieselguhr.

352—INJECTOR.—These devices are used in place of boiler-feed pumps or as an auxiliary thereto. The injector is really a form of steam jet pump, and consequently will not work successfully when the supply of water it is to handle is more than moderately warm. A pump will feed water that has a temperature slightly below 212 deg. F., and, for this reason, is more efficient. Since pumps, however, are subject to breakdowns, an injector is generally considered a necessary auxiliary to take care of these emergencies. Where condensed water is not used, an injector is very efficient, but good practice advises both a pump and an injector, or two injectors. (See also Pumps, and Ejectors.)

INSULATING BRICK, see Brick, insulating.

INSULATING CEMENT, see Cement, insulating.

353—INSULATING MATERIALS.—Felt and cork are largely used for insulation where the danger from heat is not great. The ability for insulation really depends on the amount of air cells a material can hold. (See also Hollow block and brick; Kieselguhr; Magnesia; and Asbestos.)

MANUFACTURER (see catalog section):
Celite Products Co.

INSULATION, BOILER, see Boiler insulation.

354—INSULATION, DRYER.—Very seldom do we find an excess of heat for the dryer. Even where we have a high heat as in the waste heat drying system, we should mix enough air to take up the moisture and this naturally reduces the temperature. The higher we can keep the heat in the dryer the more drying can be accomplished and the danger of water condensing removed. The walls of dryers are often used to support part of the roof of the building, and in that case are usually heavy enough to insulate the dryer, so that the heat will not escape. A coating of some material, however, should be placed on the inside of the dryer or in the wall. Heavy tar paper is satisfactory and magnesia or asbestos are equally good. The top or roof of the dryer should receive especial attention, because heat naturally rises and because the construction of a dryer does not necessitate a thick roof. Paper is not sufficient for the roof insulation. Magnesia, asbestos or one of the forms of insulating brick and insulating cements should be used. Cinders and ashes have been found of good use for this purpose also. The use of pitch or tar on the outside of the dryer walls and the top of the roof has been found to be very satisfactory as it makes the dryer waterproof and at the same time prevents the escape or infiltration of air.

From actual tests it has been determined that if one side of the outside dryer walls is plastered, 10% less heat will be radiated, and if both the inside and outside are plastered that 20% less heat will be radiated. Hollow ware affords very good insulation for a dryer wall. The outside walls below grade should be plastered with a mixture of two parts of sand and one part of cement. After this is set a layer of tar should be put over it. Kieselguhr as a paste or cement or made into a brick forms a very good insulator.

MANUFACTURERS (see catalog section):
Celite Products Co.
Philadelphia Drying Machinery Co.

INSULATION, FURNACE, see Furnace insulation.

INSULATION, KILN, see Kiln insulation.

INSULATION, STEAM PIPE, see Pipe covering.

355—INSURANCE.—Insurance is the act of receiving a guarantee from one party that he will reimburse another party for any damage or loss up to a certain amount caused by a certain specified event or act which may or may not occur. The party insured pays a definite amount called the premium to the insuring party, who is usually an insurance company. Life insurance is often used to reimburse a company for the loss it will feel from the death of one of its principal officers. Fire, tornado, windstorm and lightning insurance are used as a protection for damage caused by the several elements. Employer's liability insurance reimburses an employer for any injury to an employee while engaged in his occupation. Flywheel insurance covers any damage or loss caused by the rupture of a flywheel. Boiler insurance reimburses for any loss arising from the explosion or rupture of a steam boiler. Credit insurance reimburses for any loss arising from the failure of a customer to settle his account. Fidelity insurance reimburses for any dishonesty on the part of an employee. Use and occupancy insurance reimburses for any loss or damage arising from the inability of using and occupying certain premises.

Group life insurance has lately been employed largely to reduce the labor turnover. Under a policy of this kind the employer pays a premium based on the number of employees, and the insurance company pays a definite sum to the employee's beneficiary depending on the length of employment whenever an employee dies. The employee does not undergo any examination. He loses all of the insurance features when the employment is terminated.

356—INVESTMENT.—This item refers to the amount of money used in a business or the amount put into a certain enterprise for a profit. Investment is used at times in two different meanings, one being the same as invested capital and the other the same as capital in the broad sense. The money that is on hand at any one time, if not necessary for the conduct of the business, may be put into some other fund or outside security, and to that extent constitutes an investment distinct from the original investment of the company, or plant.

357—IRON.—Iron is a metallic substance derived from its various ores found in the earth. It is the ores and the presence of them in clays, together with their effect in the processing of clay ware, in which the clay manufacturer is chiefly interested. The most common ores found in clay are: Limonite ($2Fe_2O_3, 3H_2O = Fe_2O_3$ 85.5%, H_2O 14.5%), hematite (Fe_2O_3), magnetite (Fe_3O_4), siderite ($FeCO_3 = FeO$ 62.1%, CO_2 37.9%). Early in the burning process these ores are changed in chemical composition and the oxides of iron remain. These oxides of iron in the burning process have certain effects on the coloring of clay ware, fluxing action, and absorptive and shrinkage properties. The coloring action is of chief concern and this is described under another head. (See Burning, factors important to.) As a flux, iron lowers the fusing point of a clay and forms iron silicates of lower melting points. A low iron content is desirable in refractory clays because of this fluxing action, and in whiteware clays because of the tendency to color the ware, which in whiteware products is undesirable. The effect of iron in unburned clays is described in another item. (See Iron, coloring action of, in unburned clay.)

359—IRON. COLORING ACTION OF, IN UNBURNED CLAY.—Clays often show a yellow or brown discoloration, due to the presence of limonite; and a red coloration, due to hematite; magnetite is rarely present in sufficient quantity to color the clay; siderite or pyrite may color it gray, and it is likely that the green color of many clays is caused by the presence of silicate of iron, this being particularly true of glauconitic clays. Intensity of color, however, is not always indicative of the amount of iron present, as the same amount of iron may, for instance, color a sandy clay more intensely than a fine-grained clay, provided both are nearly free from carbonaceous matter; the latter, if present in sufficient quantity, may even mask the iron coloration completely. The coloring action of iron will, in addition, be effective only when the iron is evenly distributed thru a clay in extremely fine form. It is probable that the limonite which colors clays is present in an amorphous or non-crystalline form, and forms a coating on the surface of the grains.

J

362—JACK, LIFT.—A lifting jack is a device for raising any weight by supporting it from underneath. One or more are indispensable for setting machinery, making repairs or replacements, etc. The screw and the lever or pump jacks are the types used most. The screw jack consists of a bottle shaped casting which is hollow. The top of this hollow space is fitted with a square threaded screw into which a spindle with a corresponding screw works. On top of this spindle there is a collar which is loose and is kept in contact with the article to be raised or lowered. The spindle is turned by means of a lever and this raises or lowers the object. On account of friction and the small incline of the screw a screw jack will sustain its load at any point. The lever jack has a square lifting bar with teeth on one side instead of the screw spindle of the screw jack. A lever raises or lowers this bar one tooth at a time and a catch is provided for holding it in position at each tooth. Both screw and lever jacks are suited for handling moderate loads, the lever jack being faster but the screw jack being steadier and more reliable where there is danger of a mishap. Both types are made in a variety of capacities, the house moving jack being a variation of the screw jack. For handling heavy loads geared and hydraulic jacks are better. The former is operated by a lever working thru a set of gears by which the force is greatly amplified. The hydraulic type of jack has a lever which acts like a pump to increase the pressure exerted on a liquid by a small piston. This pressure is transmitted to a much larger piston, and thereby the force of the jack is greatly increased. Both the geared and hydraulic jacks are slow working but they are wonderful and convenient devices when it is considered that by them one man can raise and lower loads of several tons.

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

363—JAPANESE PORCELAIN.—A very white, translucent ware, characterized by high feldspar and low clay content; reproduced in France as the new Sevres body (also see Chinaware and Porcelain entries).

364—JET WARE.—Pottery goods; refers chiefly to teapots, coffee pots, sugar bowls, etc. Jet ware is composed of a good class of red clay, glazed with a jet black glaze, the color being produced by the use of cobalt or nickel. These goods are generally elaborately decorated.

JIB CRANE, see Crane.

365—JIGGERING AND JOLLYING.—Potters' terms. Jiggering is the process of shaping most commonly used in forming tableware on a jigger machine, which consists of a spindle provided with a head, into which the mold is fitted, and which must run perfectly true. Attached to an iron support behind the turning wheel is a counterbalanced arm, that swings up and down on a pivot. This lever may be pulled down until it is in about a horizontal position, when it is stopped by a set screw. This arm carries a tool holder and a tool. The latter consists of a steel plate, the outlines of which correspond to the profile to be shaped and which comes to rest above the head of the spindle. In flat work, such as making plates and saucers, the plaster mold forms the face of the ware, and the steel tool or profile forms the back or exterior. In hollow ware—cups, bowls, etc., the mold forms the exterior and the tool the interior. By placing the sheet of clay firmly upon the revolving mold and lowering the tool the desired shape is quickly produced. The thickness of the piece is readily adjusted by means of a set screw which determines the position of the arm. When the piece is formed, the mold is removed from the head of the jigger and placed in the drying room, and it then goes thru the finishing process.

Jollying.

Jollying also gets its name from the machine used, the jolly, which is similar in construction to the jigger, but has a lever, or jolly, on which is fastened a templet, or profile tool, that forms the outside of the article, the surface being formed by the mold. Flat ware, such as plates and saucers, is made by this process. The cake, or flat bar, of paste or clay is thrown upon the surface of the mold. The mold, which is convex, forms the surface of the plate, and the profile of the jolly lever is pulled down by hand and forms the bottom of the plate.

Formerly only round objects were made on the jolly and jigger, but in recent years elliptical machines have been introduced which form oval shapes, so that oval meat dishes, pudding dishes, and covered vegetable dishes are sometimes made by this process.

MANUFACTURERS (see catalog section):
Bonnot Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.

JOURNAL, see Bearing, ordinary types of, and Bearing, ball and roller.

366—JOURNAL, WATER COOLED.—Water cooled journals are used wherever the heat will affect the oil or other lubricant so that it cannot perform its work. This is especially necessary in connection with dryer fans where the heat from cooling kilns or from steam coils is pulled or forced past one of the bearings. A water cooled journal consists of a water-tight compartment which surrounds the regular journal. This water-tight compartment has pipe connections arranged so that water is flowing thru it at all times. As a result the bearing is kept at a low enough temperature to enable the lubricant to properly lubricate the shaft in the bearing. This water-tight compartment is cast in the top and bottom parts of the bearing proper.

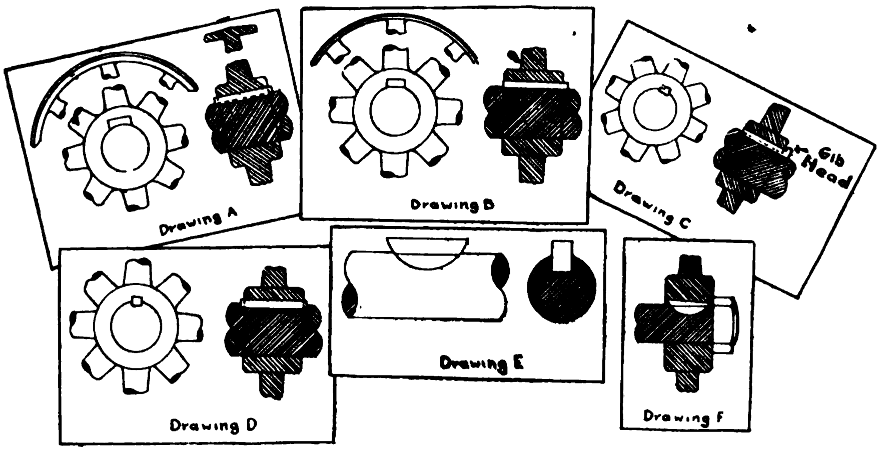
K

KAOLIN, see Clay and Kaolinite.

367—KAOLINITE.—A hydrated silicate of alumina, chemically known as $Al_2O_3 2SiO_2 2H_2O$, which is equivalent to a composition of 46.3% silica, 39.8% alumina, and 13.9% water. Kaolinite is sometimes referred to as a substance of clay, being that portion which is not soluble in hot sulphuric acid and sodium carbonate. It is naturally white in color, and a mass of it is only very slightly plastic when wet. It crystallizes in the monoclinic system, the crystals taking the form of small hexagonal plates, with a hardness of 2-2.5 and a specific gravity of 2.2-2.6. (See also Clay.)

368—KENT MILL.—This type of grinding machine has a large metal ring which operates vertically. It is about five feet in diameter and ten inches wide, and the inside face is made concave about 1½ inches in the center. This ring is supported and kept in place by three rings whose outside diameters fit the inside of the large ring. Heavy springs keep a tight tension at all times between the three small rings and the one large one. The machine operates at high speed thru one of the small wheels which drives the large rings by reason of its contact, and the large ring drives the other small rings or wheels by reason of the contact also. The clay is fed between one of the small wheels and the large outside ring, and on account of the high speed the machine carries the clay around between the three wheels and the ring. When the clay is ground fine enough it falls out over the edge of the ring into an elevator pit. This machine is especially satisfactory for grinding hard clay, stone, etc.

369—KEY, GEAR AND PULLEY.—An oblong piece of iron or steel, which, when driven in with a hammer between a groove in the gear or pulley and a groove in the shaft, serves to "freeze" either of them to the shaft, making possible high speed operation or heavy pulls. The large majority of sprockets and pulleys for clutches are also fastened to a shaft by means of a key. There are several types of keys described and illustrated herewith.



The saddle key as shown in Drawing A is used only when the holding power is small and where it is not desirable to cut or mar the shaft. This key is hollowed out to fit the shaft and holds by friction alone. Keys in this design never give any trouble when removing pulley from shaft. They are used on some of our very smallest power driven machinery.

The flat key (Drawing B) rests upon a flat which is formed on the shaft to receive the key and therefore has a greater holding power than the key just described. When repairing most of the smaller power equipment on the plant, this type of key can be used, because it is not necessary to cut a keyway. A flat is filed on the shaft, as shown in the figure.

The sunk key (Drawing C) is the most common form used where the forces to be resisted are large. A slot called a keyway is cut lengthwise in the shaft, and another to correspond is cut in the piece to be secured. The key is then fitted to the opening formed by the keyways. The cutting of keyways is a machine shop job; sometimes, however, this job can be done by using the cape chisel and flat chisel. This is a very difficult and trying operation, so it is not recommended. This type of key can be tapered or straight. The taper key is sometimes provided with a head, as shown in the figure, to facilitate its removal when the point cannot be conveniently reached for the purpose of driving it out. This headed key is known to the trade as a gib headed key. The amount of taper to these keys is usually about ⅛-inch per foot of length.

The square key is shown in Drawing D. This key should fit accurately on the side to prevent the key from rolling over in the key seat. It should be fitted to bear lightly on the top and bottom. These keys are made from square soft steel stock, and it is not necessary to do much filing or fitting if the keyways have been cut properly in the pulley and on the shaft. This key will be found on some of the larger power machinery in the clay plant.

The Woodruff key as shown in Drawings E and F is a new type of key which is used mostly on tractor engines and finds little use in clay products manufacture. (See also Keyseater, portable shaft.)

MANUFACTURERS (see catalog section):
Link-Belt Company.
Weller Manufacturing Co.

370—KEYSEATER, PORTABLE SHAFT.—Many times after a plant is erected a pulley or gear must be moved to another location, and if it has been fastened to the shaft by a key, it is often necessary to cut a new keyway. It would be impractical to dismount the shaft and take it to the machine shop and cutting the keyway by hand tools is a long and tedious job. It is often hard to obtain a perfect fit in a handmade keyway. A portable shaft keyseater is a very great convenience in a case of this kind, and its operation does not require as high a grade of mechanical skill as does hand cutting. A frame is clamped onto the shaft which holds four boxes. In these boxes four steel rods which carry the cutting arrangement travel back and forth for the length of the cut for which the machine is fitted, generally 12 inches. The cutting arrangement consists of mill cutters which are interchangeable for the various sizes of keyways. The proper size of cutter is mounted on a casting which slides back and forth with the four steel rods spoken of above. Portable keyseaters are made to be driven by hand or by any type of electric current available, as a motor can be mounted on the cutter slide. The feed is automatic and the machines are made in several sizes to fit shafts up to 12 inches in diameter.

MANUFACTURERS (see catalog section):
Link-Belt Company.
Weller Manufacturing Co.

371—KIESELGUHR.—A diatomaceous earth used largely in the manufacture of insulating brick (see Brick, insulating). Kieselguhr is formed by the precipitation of diatoms, which are aquatic plants and which grow in all waters. Over 4,000 distinct forms of diatoms have been recognized, varying in size from a pinhead to a minute particle hardly visible thru a microscope. These diatoms multiply rapidly and float around until the organisms die and the shells accumulate. The accumulation of these shells is generally contaminated. In California, an immense deposit of fairly pure grade is found. In its natural state, kieselguhr contains 25-40% moisture, which is expelled at 100 deg. C. (212 deg. F.), and is pure white to brownish in color, very light in weight, and a soft, easily abrasive material. Kieselguhr is used extensively in the manufacture of lightweight tile, brick, partition tile, as a filler for any kind of bonding material, and as an addition to Portland cement. It is also used as a thermo insulator.

The microscopic or dead air cells within the diatom prevents the passage of heat, making it one of the most effective insulators known. It is also used for many other purposes. It is a component of some of the insulating cements and brick, now on the market.

MANUFACTURERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Celite Products Co.

372—KILN.—A kiln is a large furnace or heated chamber or series of chambers—round, oval or rectangular in shape, and built principally of brick—which is used for the purpose of thoroly drying, hardening and burning clay wares. Kilns may be divided into two main classes, intermittent and continuous, each class being subdivided into a number of general groups, as up-draft, down-draft, horizontal draft, etc., as indicated in structural and operative detail presented in various kiln entries that follow.

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Bonnot Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Rodgers, L. E., Engineering Co.

373—KILN ACCESSORIES.—Classed under this item are the irons and bands for bracing the kiln, including patent methods of fastening the bands, the grate bars, floor tile, fire brick, peep hole blocks, iron frames for the holes in the crown, covers for these same holes, castings for continuous kilns, clinkering bars, scoops, skew blocks to support the crown, arch blocks to use in place of brick in the fire box, dampers, etc.

In many down-draft and continuous kilns the holes thru the crown are constructed of fire clay blocks in order to make the crown more permanent. (See also Fire brick.)

MANUFACTURERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Brown Instrument Co.
Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Robinson, Frank H.
Rodgers, L. E., Engineering Co.
Toronto Foundry & Machine Co.

374—KILN, BISCUIT AND GLOST.—These kilns are used in the manufacture of earthenware and chinaware or porcelain. After having been shaped and dried, the pieces of ware, still in their clay state, are burned in the biscuit kiln; then, after having been decorated and dipped into the glaze, they are transferred to the glost kiln where the firing temperature reaches the peak necessary to convert the glaze into a vitreous, translucent, integral part of the ware.

Kilns employed for biscuit firing are generally of the up-draft type, and range from 14 to 24 ft. in diameter, interior measurement. The height from the center of the floor to the center of the crown may be 17 ft. or more. Biscuit kilns, as a rule are larger than glost kilns, many of the former being 18 ft. in diameter, while the latter run about 14 ft. In England and Germany down-draft kilns are successfully employed for biscuit firing, but this style has not found general acceptance in this country. The stack is commonly built on the kilns proper in the form of a hood. The furnaces are usually seven to nine in number. From kiln floor to top of stack, the height is ordinarily about 50 ft. In the up-draft types, the flames from the furnaces reach the burning space proper partly thru large openings, or bags, around the circumference of the kiln, and partly thru small openings in the kiln floor. In the down-draft types, the entire volume of gases is forced to rise thru the bags toward the crown and to escape thru openings provided in the kiln floor.

The ordinary pottery kiln for burning earthenware and "hard" biscuit china is composed of one chamber. For "easy" biscuit firing, the kiln, or oven, is built with two and sometimes three chambers, one above the other, the fire being applied in both cases to the lower chamber only. In the case of "hard" fired biscuit, the temperature is run up to a very high degree and beyond that to which the second, or glost, firing is taken. In this case the "green" wares (or modeled pieces of clay) are placed in the kiln in clay receptacles, technically known as saggers, and after the first burning must be well scoured and cleaned before being dipped in the liquid glaze and put thru the second, or glost, firing.

By the "easy" biscuit process, the "green" ware is placed in the second or upper chamber of the kiln or oven, thus utilizing the waste heat from the lower chamber. The lower chamber is used for firing the glazed ware. In cases where three chambers are built in one oven the top chamber is used for burning the fire clay cases, or saggers. The biscuit ware taken from the second chamber after burning is not very hard and can easily be broken between the thumb and finger. After being dipped in the glaze (which is composed chiefly of the body materials with a large proportion of fusible elements), the ware is placed in saggers in the lower chamber and carried to a high degree of temperature, thus producing a homogeneous mass of body and glaze as the finished product.

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Rodgers, L. E., Engineering Co.

375—KILN, BISCUIT AND GLOST, PLACING.—Biscuit-kiln placing is the process of putting the finished ware in the saggers, and placing the filled saggers in the kiln, or oven. These saggers are usually placed one above the other, each being carefully sealed by wads of clay. The firing chamber of the average kiln ranges from 15 to 17 ft. in height and from 15 to 18 ft. in diameter, and holds from 2,000 to 3,000 saggers, according to their size and capacity. After the kiln, or oven, has been filled, the door is hermetically sealed and the iron bands clamped together. The process of the first fire occupies from 50 to 65 hours, according to the size of the kiln, the kind of ware to be fired, and the amount of heat required. These kilns are cooled gradually (for a period of about 48 hours) before the ware can be handled and removed.

Glost-Kiln Placing.

The ware when dipped has the appearance of being covered with a coat of whitewash, the brilliancy or glassy effect being produced in the process of firing. The dipped ware is taken from the dipping room and again placed in saggers especially prepared for this purpose. The inside of these saggers is coated with a thin film of cheap glaze composition. The ware itself must be separated one piece from another; otherwise in the burning process the glaze would melt and bind the articles together. This separation is accomplished by the use of stilts, pins, spurs, and thimbles in the case of earthenware, but separate saggers must be used for each piece of chinaware. For example, in earthenware, a single sagger will hold, say, seven 3-in. plates; but with china it is necessary to use seven small individual saggers. In the latter the plate rests on its own feet, having first been wiped clean of glaze; in the former the rim of the plate rests on three points of the pins or thimbles, and thus the plates can be placed one above the other. Glost-kiln placing requires a little more care and experience than biscuit-kiln placing.

BUILDER (see catalog section):
American Dressler Tunnel Kilns, Inc.

376—KILN BRACING.—All kilns must be braced to counteract the expansion due to the heat on the inside. Up-draft kilns need less bracing than down-draft, and usually the side walls are made heavy enough to take care of this. In down-draft kilns, whether rectangular or round, and also in pottery kilns, special bracing must be placed at the skew line of the crown to counteract the thrust of the crown when the heat is raised to the desired point. The fire boxes and the walls at the level of the floor line also need special attention on this subject. Continuous kilns and tunnel kilns must also be braced especially to counteract the thrust of the crown.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
Toronto Foundry & Machine Co.

377—KILN, CONTINUOUS.—The central idea in the construction of the continuous kiln is to utilize as much of the heat of the waste gases and of the cooling ware as is possible. This is accomplished by joining together a number of compartments so that the gases of combustion may be carried ahead of the burning chamber thru green ware which will absorb much of the heat that in other kilns is turned into the stack. The air for combustion to reach the zone of highest heat travels thru chambers of cooling ware. In this manner the continuous kiln makes use (1) of a large amount of heat saved from escaping gases and also (2) utilizes the heat given off by the cooling ware.

Types of Continuous Kilns.

Of the several makes of continuous kilns used in this country, the essential features of operation in all are similar. They are built circular, oval or rectangular in shape and contain a varying number of compartments. Whatever the general outline of the kiln as a whole, the number of chambers is sufficient to allow a space of a few compartments between the rear and the head of the fire for removing the burned ware and setting the green ware. In some types, the compartments are separated by brick walls; in others, no permanent partition walls are used. In the latter, the size of the chambers and the division lines between them are made by paper or wood partitions which burn out when the temperature reaches a red heat. In some continuous kilns, the draft is prevailingly downward; in others, upward. In all, however, the method of burning consists of carrying the fire continuously round thru a series of connected compartments; those compartments in the rear of the hottest portion contribute their cooling heat to the entering air, and the gases ahead of this zone of greatest heat give up their energy to prepare the fresh ware for the advancing fire.

The Dew Point.

The limit to the distance which the gases may be carried ahead of the fire is the point where they approach saturation. It is clear that in a continuous kiln there is going on at the same time all three of the typical stages of the burning process—dehydration, oxidation and vitrification. The gases as they finally reach the stack may have a complex composition. They may contain sulfur gases from the oxidation of sulfur in the coal and from the decomposition of sulphates in the clay. They will contain water, both the hygroscopic and combined water of the clay. It is the presence of water that determines largely the distance ahead to which the gases can be carried safely. Their heat is taken up to a great extent by the evaporation of moisture, and they become rapidly cooler as the humidity increases. They can not economically be allowed to reach the dew point, as the dew point is universally acid, and, in addition to the other harmful effects ascribed to an acid dew, an abundance of it would probably result in the softening of the ware. The gases must therefore be turned into the stack before their dew point is reached, and preferably while their temperature still sufficiently exceeds that of the atmosphere to create a draft. It is the effort of continuous kiln designers and burners to approach this limit as closely as possible without overstepping it.

Location of Stack.

The necessity of operating the continuous kiln with stack temperatures much lower than in the periodic kiln makes it necessary to build the stacks larger and higher in order to furnish ample draft. This is also required because of the distance the gases have to travel, oftentimes thru devious flues and also thru large amounts of ware. Frequently the stack is located in the center of the kiln, sometimes at the end. In most makes of continuous kilns it is not necessary to place the flues that lead to the stack below the level of the kiln floor; therefore the cooling effect of underground flues on the gases passing thru them is avoided and no heat is lost by the absorption of moisture from the soil.

Firing the Kiln.

In many continuous kilns the fuel, which is commonly slack coal, is fired right among the ware, being charged thru small openings in the top of the kiln. The setting is usually such that the coal is distributed from top to bottom by portions of it lodging on the projecting brick of different courses.

In burning face brick or other higher grade wares that would suffer from contact with the fuel, furnaces are used. The fuel is charged from above as before but within small compartments or bags from which only the gases pass among the heated ware.

It is practically impossible in the continuous kiln to separate sharply the typical stages of burning. The chemical reactions characterizing the different parts of a burn are all going on at once. Dehydration, oxidation and vitrification are taking place in the same kiln atmosphere. Experience has proved that while certain parts of a burn may be hurried, others should be carried on very slowly. Thus, it is frequently found necessary to hold back one portion of a continuous kiln while other parts are prepared for the advancing heat. To avoid such trouble auxiliary fireplaces are sometimes supplied in which fuel is burned to heat up the wet ware ahead of the main fire. In other instances, warm air is brought from the cooling chambers and turned in ahead of the fire. This is only possible where the ware will stand more rapid cooling than the air passing thru it to supply the fire will bring about.

Continuous kilns are built for burning all classes of clay ware in varying capacities. See other items about continuous kilns regarding firing by producer gas, side-fired coal, etc. The above is the movable fire type kiln. (See also Kiln, tunnel.)

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Rodgers, L. E., Engineering Co.

BUILDERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton, Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

378—KILN, CONTINUOUS DECORATING.—A type of kiln used in England, Austria, and (more successfully) in Germany in burning decorated whiteware, earthenware, and china. The ware is placed in iron cages or crates, and after being entered in the kiln a crate of ware is finished in about 15 minutes. Similar kilns are in operation in earthenware potteries of the Netherlands, but, to date, no continuous decorating kilns have been installed in any whiteware pottery in United States. One of the English kilns has a continuous gap three inches wide in the center of the roof of the tunnel thru which pass 28 hangers. These hangers support 28 platforms on which the baskets holding the ware are placed. The hangers are attached to an iron superstructure above the kiln, carried by a central pillar that revolves on ball bearings. There is but one charging door for placing in and removing the baskets of ware, and there is only one firing mouth. To fire the full outfit of 28 cages of ware requires about 9 hours and 20 minutes, as compared with 20 hours in a regular box kiln. About five tons of coal is used for this charge as compared with 20 tons in the regular kiln. The continuous kiln required a coal costing $4.26 per ton, against coal costing $3.53 per ton for the regular box kiln. American and English potters in general contend that the continuous decorating kiln has not been demonstrated to be thoroly practical, but if continuous biscuit and glost kilns can be put into successful operation, they no doubt will be universally adopted.

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
International Clay Machinery Co.

BUILDERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton, Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

379—KILN, CONTINUOUS, DESIGN AND CONSTRUCTION OF FOUNDATIONS.—There are two very important factors in the design and construction of this type of foundation; first, the weight of the structure; second, its continual movement. When calculating the weight of the load the foundation will carry, the figures must be based on the kiln filled with ware. It is never safe to figure on a load of less than 100 lbs. to the cubic foot; it is safer to figure 150 lbs.

The valley bottoms on which kilns are generally located are often composed of sand, sandy clay or clay washed from the hillside. Very often these materials offer a treacherous support for a heavy structure, especially when every effort must be made to prevent unequal settling.

If a rock or shale bottom cannot be reached without incurring great expense, consult an engineer's table to find the allowable load for the type of material on which the kiln is to be built. It will then be a simple matter to figure the area which the foundations must cover in order to support the kiln properly. Where very soft ground is encountered, it may be necessary to build a "raft" of concrete on which the structure will "float." In all cases of doubt, consult a reputable engineer. Avoid "standard" kiln designs, drawn up without reference to the job in hand. Also avoid staggering repair bills by building a foundation heavy enough to support flue walls, floor and ware; these items should always be part of the general foundation plan—not separate.

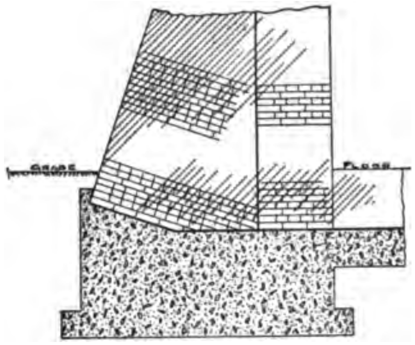


Fig. 1. Correct Construction of Foundation for Batter Walls.

It is also important to provide "backing" for the foot of the batter walls; otherwise there is nothing to prevent the batter wall from shearing off at this point whenever it gets the expansion thrust. There are many instances where these walls have moved from six inches to one foot from their original location. See Fig. No. 1 for method of providing a footing for batter walls.

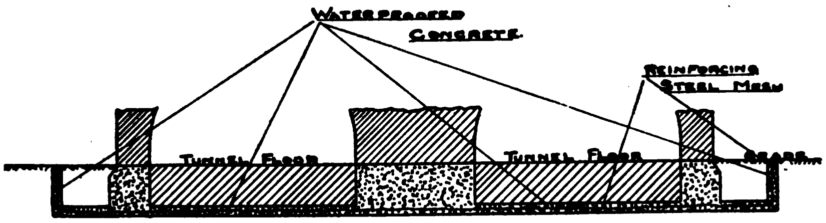


Fig. 2. Method of Constructing Weatherproof Bottom.

Drainage Important.

Most kilns of this type are built with solid floors, which often leads the clayworker to think that moisture under the kiln will not bother him. This is an error. When a kiln is under fire, heat sufficient to evaporate water will penetrate to a depth of at least ten feet. The water vapor thus formed is drawn into the kiln by the slight vacuum existing in the chamber or tunnel. Sometimes the amount of this vapor is sufficient to make it impossible to get from three to six of the bottom courses beyond the salmon stage. This causes a serious loss of ware, reduces the burning speed, and increases fuel and labor costs.

A kiln bottom should be drained to a depth of 10 or 12 ft. by running 4-in. tile drains from 18 to 24 ins. apart under the whole bottom of the kiln. These drains should not have less than one per cent. fall; the more fall the better they will do the work. All laterals are run into one main drain large enough to handle the entire drainage system. The upper end of the main drain is connected to the main draft flues; this insures a slight circulation of air in the system and prevents the rise of vapor to the kiln floor.

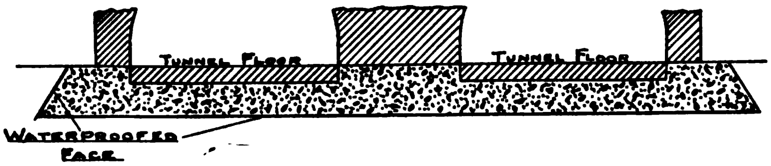


Fig. 3. Method of Constructing Weatherproof Bottom.

Where it is impossible to get a natural fall for a drainage system without great expense, the drainage water should be run into a well or sump and a pump used to keep the water below the proper level. Increased capacity and better ware will pay for the pump operation many times over.

A kiln located on gravel in close proximity to a stream and on approximately the same level, should be completely surrounded with weatherproofed concrete walls and bottom (see Fig. No. 2). Another method (see Fig. No. 3) is to build the entire kiln on a thick bed of concrete which extends far enough out from the walls to insure dryness in the chamber or tunnel.

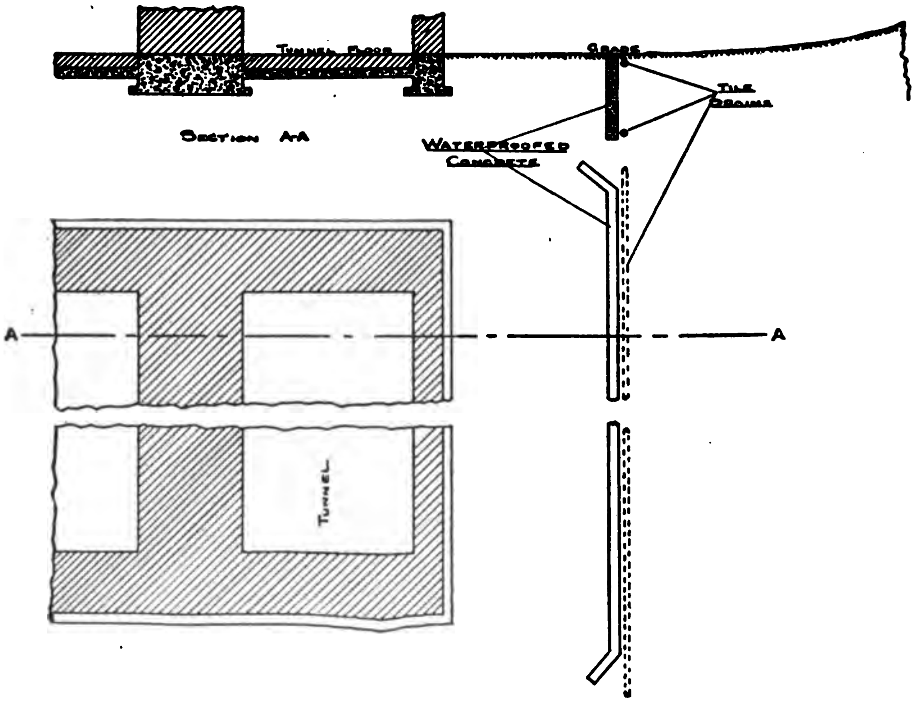


Fig. 4. Hillside Wall for Protection Against Drainage Thru Kiln Bottom.

When a kiln is to be located with a hillside on one side and a stream on the other, provision must be made to take care of the water that is bound to flow from the hill to the stream. Besides a regular drainage system under the kiln bottom, a concrete wall should be built between kiln and hill. This should slightly exceed the full length of the kiln (or width, as the case demands), and should extend from the grade level to a depth of 15 ft. On the side of this wall which faces the hill, a drainage system (see Fig. No. 4) should be provided to catch and divert all water flowing towards the kiln.

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:

- International Clay Machinery Company, Dayton Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

380—KILN, CONTINUOUS, DESIGN AND CONSTRUCTION OF MAIN WALLS.—Two types of exterior walls are used in continuous kiln construction: (1) the straight, buck-stayed type, like those of the ordinary rectangular kiln; (2) the battered type which requires no buckstays. There is practically no difference in cost, the thickness of the batter wall being about counterbalanced by the iron work of the straight wall. The straight wall saves yard room, and has a better appearance. The thickness of the batter wall provides better insulation, but a straight wall may be provided with 4 ins. or more of insulating brick. One consideration is that with the thick walls the transfer men and wheelers must travel further; this takes time and is a fixed charge as long as the kiln lasts. In deciding on the construction of the walls, the type of kiln and the location of the wall must be carefully considered.

It is customary to build the side walls with a one-in-three batter on the outer or exposed side, while the inner sides are vertical. In the past many kilns were built with outer and inner walls entirely separate, the space between being filled with clay, cinders, sand or rubbish; a large percentage of these have become inefficient and some of them more or less complete wrecks, due to lack of knowledge on the part of the builder, or poor workmanship.

The fact that the outer and inner walls expanded differently on account of the difference in temperature was overlooked, with the result that the brace walls were tied to both. These were soon torn to pieces,. leaving only a lot of loosely packed rubbish to keep the walls at the proper distance and the tunnel crown in place. Moreover, the loose filling worked its way into the inner walls and soon destroyed them. Kiln after kiln has either partially or entirely collapsed on this account.

The brace wall is condemned among experts because it has been proven that in the great majority of cases not enough care will be taken to make a perfect job. When care is taken to make a good job, the cost about equals that for solid brick walls. As the principal idea of the heavy wall is insulation, a thinner and stronger wall can be built solid, with an inner lining of insulating brick, that will give better results, so far as insulation is concerned, also better burns, longer life, and will cost less.

Fig. No. 1 shows the best method of constructing "filled" walls.

The outside or batter wall should be 13 ins. thick, with mortar joints at right angles to the face. Header courses need not be put closer than every fourth course. All brick should be hard, and the mortar a mixture of three parts sharp, clean sand to one part Portland cement. To improve its troweling qualities, 10% of lime putty may be used. Under no circumstances, however, should lime mortar be used, since the kiln will probably be under fire and subject to expansion strains before the mortar reaches any way near its maximum strength. The inner or tunnel walls proper should be not less than 27 ins. thick, and laid up with alternate header and stretcher courses thruout. No other bond should ever be used, since these walls are continually "rolling" forward and backward thru expansion as the fire passes around the kiln. The inner side of the tunnel wall should be lined with brick of a refractoriness suitable to the material to be burned. This lining never should be of common brick. Ordinarily, second or third quality brick are sufficiently refractory, and in cases where only ordinary heats are used the stretcher courses need only be faced with four inches of fire brick. Back of the fire brick, only first-class hard brick should be used — avoid "bats" and soft culls.

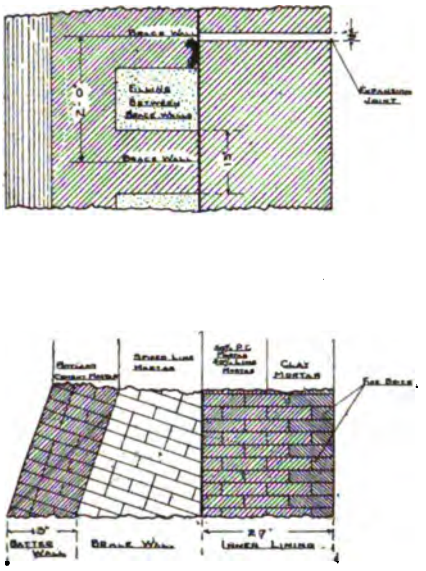


Fig. 1. Section of Wall.

The brick (both refractory and common) on the inner half (or 13½ ins.) of the walls should be laid up in fire clay, or fire clay and shale dust. The horizontal joints should be as thin as it is possible to make them with a trowel and mallet. The vertical joints should be about ¼ in. wide, to allow for horizontal expansion of the kiln. After burning, each joint will shrink about 10% of its green width, thus providing thousands of minute expansion joints in the length of the kiln.

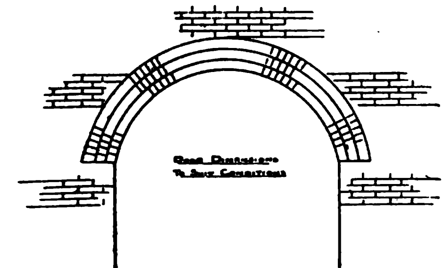


Fig. 2. Door Construction.

The outside 13½ ins. of this wall should be laid up in a mixture of 50% three-to-one Portland cement mortar and 50% three-to-one lime mortar. This mixture has given excellent results where both Portland cement and lime mortars failed. A lime mortar would do the work if really given a chance to harden before being subjected to heat. A clay mortar does not get sufficient heat in the outside of the wall to harden; it merely dries and loses its bonding qualities.

Expansion joints 1½ ins. wide should be left in the tunnel walls every 20 ft. These should always be made to come in the center of one of the brace walls which extend from the outside walls.

Building Brace Walls.

Brace walls should be built between the batter walls and tunnel walls on 2-ft. centers. Brace walls should be 13½ ins. thick and tied to the batter walls, being bonded perfectly with them and the mortar joints running in the same direction. These walls should not be tied to the tunnel walls. They should, however, be built solidly against the tunnel walls, since they really take the place of the irons on a rectangular down-draft kiln. They both keep the tunnel walls in place and take the thrust of the crown.

Between batter walls and tunnel walls, the spaces are filled with ground clay or a mixture of ground clay and sand. This filling should be done as the walls rise, but not before the brickwork is sufficiently strong to allow its being tamped lightly to insure its being solid.

Shale or clay, put thru a dry pan or other grinder, makes the best filler. It should be just damp enough to form a ball when squeezed in the hand. This kind of filler will harden into a solid mass and not work into every crack of the brickwork and tear the kiln to pieces.

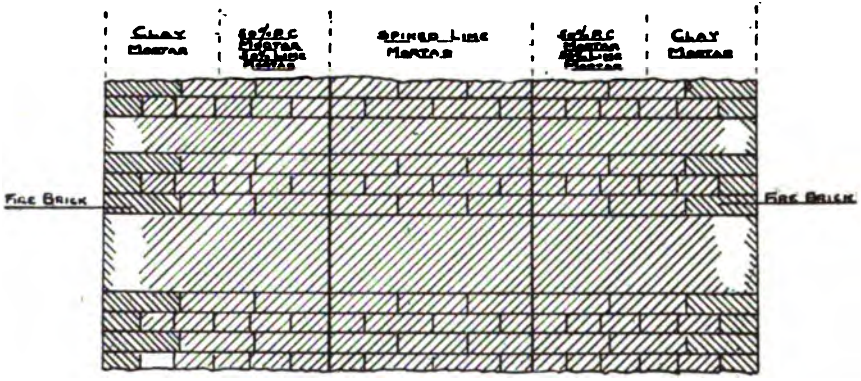


Fig. 4. Section Thru Inside Wall Double Tunnel Construction.

Door walls should be 13 ins. thick and well tied to both batter and tunnel walls. A triple rowlock, Fig. No. 2, should be used in door arches. Too much care cannot be given the construction of door walls.

Solid Brick Better Filling.

Replacing the clay filling between the batter and tunnel walls with solid brick (as shown in Fig. No. 3) results in a decided improvement. There is little difference in cost, especially if No. 2 brick are available. The construction of batter and tunnel walls is the same as previously described, but the brace walls are left out and what might be called a continuous brace wall is built in their stead.

The inner section of the wall is a continuation of the batter wall, the bond being continued thru the entire thickness. It should be built solidly against, but not tied to, the tunnel wall, the latter being free to move back and forth. The outer 13 ins. of the batter wall should be laid up in cement mortar, the balance being laid in lime-cement or "spiked" mortar. Great care must be taken to have all brick laid up in full mortar joints. Slushing the mortar over the course so as to fill the joints will not do in continuous kiln construction. Close, neat brick-laying, and the use of brick chips rather than mortar to fill up wide joints or cavities, should be insisted on. A course of "bats" in a thick wall, laid with the same care as is given whole brick, can be used quite frequently if they are always tied top and bottom with whole brick. To use course after course of bats, as is often done, produces only poor results.

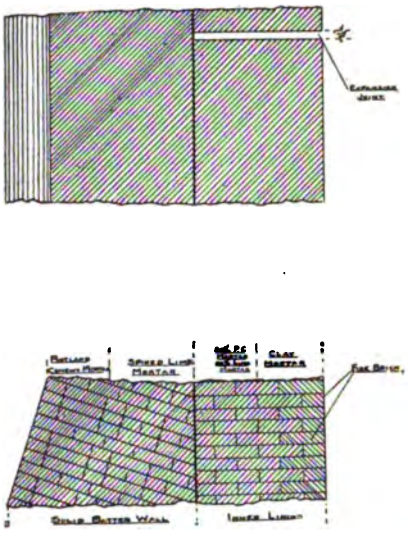


Fig. 3. Section of Solid Wall.

Where double tunnel construction is used (two tunnels side by side) the filling between the tunnel walls should always be of solid brick. Each tunnel wall should be built separately, with the brick filling between independent of them (see Fig. No. 4). To tie these walls together will wreck any kiln very quickly.

Both straight buckstayed and battered walls are used in the construction of the side walls of a chamber kiln. When battered walls are specified, the construction should be the same as that described for the tunnel kiln. The expansion joints should be located at the points where the cross walls which separate the chambers are set into the side walls (see Fig. No. 5).

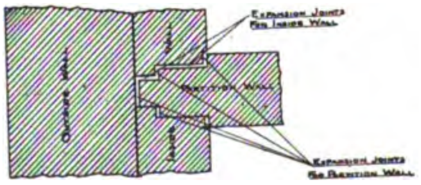

Expansion Joints For Inside Wall
Partition Wall
Expansion Joints For Partition Wall

Fig. 5. Showing Location of Expansion Joints.

The same construction is used in straight kilns.

Thin Insulated Wall Best.

When straight walls are to be used, a thin insulated wall will give yard room and practically prevent radiation losses. Considered from the viewpoint of appearance, space, working conditions, and rapidity of construction, the thin insulated wall is best for the chamber-kiln sidewalls. It requires, however, the utmost care in construction. Straight walls should never be less than 36 ins. thick. Also, instead of building the inner wall separate from the outer, as in the tunnel kiln, the entire wall is tied together as in the case of a rectangular down-draft kiln, with alternate courses of stretchers and headers (see Fig. No. 6).

The header courses, as illustrated, should be continued thru the entire thickness of wall. In selection of fire brick, the same rules regarding thickness and quality should apply as in the case of the tunnel kiln, described above. Insulating brick should be used as the insulator; 4½ ins. of this material would be sufficient, but in order to get a perfect bond, it is necessary to use 4½ ins. on the stretcher courses and 9 ins. on the header courses. They should be laid as shown, as they are not as strong as building brick and this connection is stronger than a straight bond.

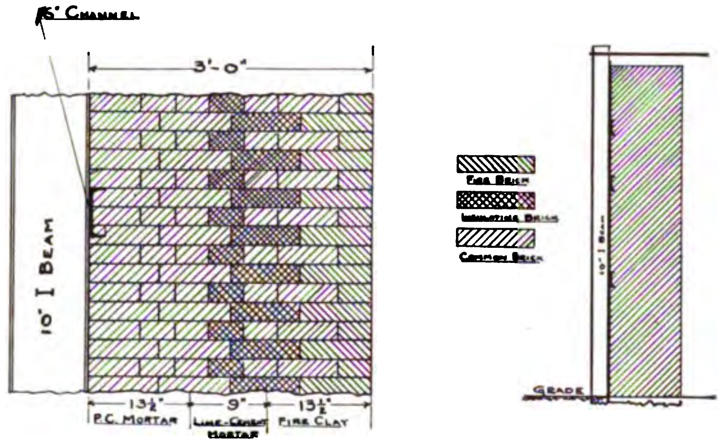


Fig. 6. Section of Straight Wall Kiln. Also Section Showing Iron Work.

The principal ingredient of the standard insulating brick is a diatomaceous earth known as kieselguhr. Four inches of this material is equal to from 32 to 48 ins., and nine inches of it equal to from 72 to 108 ins., of common brickwork, insofar as insulating qualities are concerned.

Ten-inch I-beams should be used as buckstays in the construction of a straight wall chamber kiln; these should space ten feet on centers for satisfactory results. They should also be set in heavy concrete footings to a depth of at least three feet, and tied together at the top with 1½-in. rods having a turnbuckle in the center. Avoid tying beams to bottom of kiln walls by means of a ring-bolt and a plate buried in the masonry; this simply fastens them to the wall they are supposed to hold.

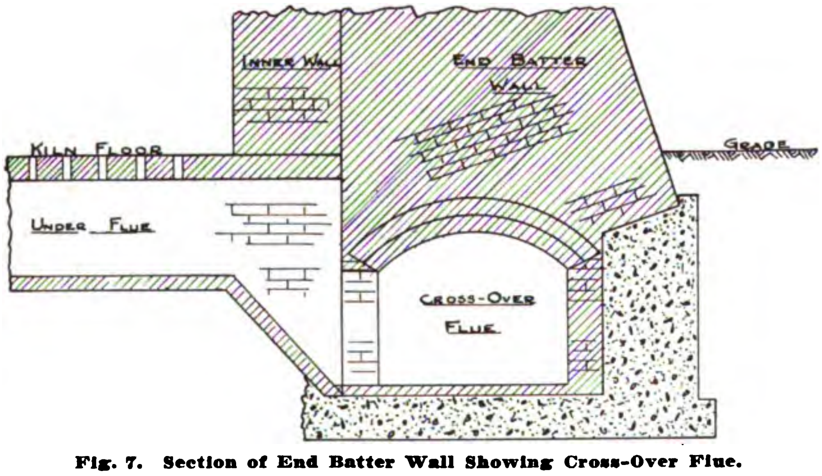


Fig. 7. Section of End Batter Wall Showing Cross-Over Flue.

Six-inch channels should be built into the face of the wall, flat side out, at the height of the door-arch skewbacks, and extending from door opening to door opening. One channel of the same size should be run the full length of the kiln just above the door arch, and another halfway between it and the top of the kiln.

End Walls of Tunnel and Chamber Kilns.

In the newer and more approved types of kilns, the end walls are always battered and built straight across the end. This construction gives far greater stability than the circular end, and is much easier to hold in place. The expansion of the great mass of brickwork in kilns from 150 ft. to 400 ft. long exerts an enormous thrust on the end walls, and will quickly wreck any except the best construction.

In the case of the chamber kiln, where the chambers and crowns run at right angles to the side walls, the whole thrust of from 8 to 20 crowns must be taken entirely on the ends, and any accident to these walls would cause the crowns to collapse like a house of cards.

The "cross-over" flues or those used to carry the heat from one tunnel to another, or from one battery of chambers to another, are sometimes built within the end walls. Whenever a flue is to be built within the walls, it should be so constructed that the top of the arch comes entirely below the floor level. To build such flues where they will have to take some of the expansion thrust, is to invite disaster. Fig. No. 7 shows the proper construction.

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

BUILDERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

381—KILN, CONTINUOUS, DESIGN AND CONSTRUCTION OF PARTITION WALLS, FLUE WALLS, AND CROWN. —The partitions, or walls which divide the chambers present no difficulty in a coal-fired kiln. They need not be very heavy, 22½ ins. being sufficient. Their chief duty, aside from separating the chambers, is to support the crowns. They are simply middle walls with a crown springing from each side; thus, the thrust is equally balanced and need not be considered.

In the case of the one side gas-fired chamber kiln, the conditions are different. In these walls are built the gas "down-takes" leading from the distributing flues, which flues are built between and parallel with the crowns. The down-takes are usually nine inches square and open at the bottom into the bag walls.

The only safe method of constructing these small flues is by the use of tongue and groove brick (see Fig. No. 1). These brick make a perfectly gas-tight joint.

As partition walls are built up, the "down-take" flues should be carried up separately, as the tongue and groove brick will not bond with standard shapes. This is an advantage, as a crack that might develop in a flue wall would not extend thru the partition wall proper. The flue walls need only be 4½ ins. thick, and as tongue and groove brick are made very exact in size, they should be dipped in the mortar. The partition walls should be laid up with a trowel and mallet and the bond should be the same as the lining, alternate courses of stretchers and headers. They should be set in sidewalls as shown in fig No. 2. When 9-in. by 9-in. down-take flues are used, the total wall thickness should be 36 ins.

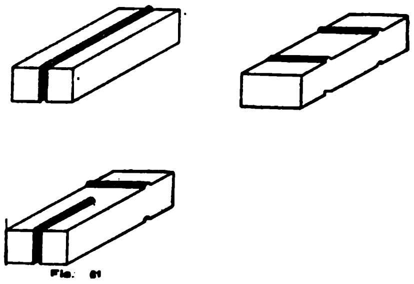


Fig. 1. Tongue and Groove Shapes.

In gas-fired, and in some coal-fired, chamber kilns, bag walls or pockets are built on one or both sides of each chamber and attached to the partition walls. These bag walls being built comparatively close to the partition walls, are more stable and not subjected to the same destructive influences as in the case of bags in the periodic kiln. The bag wall may be built as a continuous wall, but it should be thoroly tied into the partition wall from top to bottom by means of 4½ in. partition placed between each burner or pocket (see Fig. No. 3). In some cases each burner or pocket is provided with an individual bag wall completely surrounding it. The face of a bag wall should be nine inches thick and also be alternate header and stretcher courses. Bag walls in these kilns, when properly built, will last for years with only minor repairs.

Flue Construction.

Continuous kiln experts generally advise placing flues as low in the body of the kiln as possible. This has a tendency to make them less accessible, but also less likely to be damaged by constant expansion and contraction. In coal-fired kilns the only flues used are the main draft flue with its connections, and the water-smoking flues when provided. These offer no constructional difficulties and may safely be made part of the brickwork which surrounds them. Extra care must be exercised when connecting one flue to another so that no break will occur; also to use the exact arch, wedge and rectangular shapes required to make a perfect arch. The use of straights alone will invariably lead to trouble and repairs. Manholes, giving access to the main and water-smoking flues, can be left so as to make it an easy matter to get into them.

A different problem is met with in a gas-fired kiln; and in late designs, all gas and water-smoking flues are carried in the walls. In older models of the chamber type, the main gas flue and water-smoking flues were carried on top of the kiln, and made of steel with a brick lining. This prevented loss of heat and gas leaks, and as they could expand and contract freely without reference to the kiln, they gave no trouble.

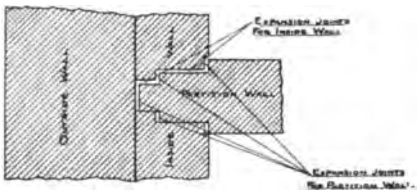

Expansion Joints For Inside Wall
Outside Wall
Wall
Inside
Partition Wall
Expansion Joints For Partition Wall

Fig. 2. Showing Location of Expansion Joints.

Brick Gas Flues Hard to Build.

The walls of the main gas flue, which always runs full length of kiln, should be built of tongue and groove brick, should be nine inches thick, and have alternate header and stretcher courses. The floor of flue should not be tied to wall on which it rests, but should be free. The arch should be built with extreme care and with joints as thin as possible. The walls of the flue must not be tied to the brickwork on each side. This brickwork should be run up on each side of flue with a straight, close joint, without mortar between it and the flue. If the flue is to be surrounded by brickwork—that is, placed low down in body of kiln—another arch should be thrown over the flue arch, but entirely separate from it. Such a flue will be free to move without reference to adjacent brickwork; and it must be free if it is not to be a constant source of trouble and expense.

Constructing Water-Smoking Flues.

The water-smoking flues, when built in body of kiln, must be constructed in exactly the same way; otherwise, they will become more of a nuisance than a help on account of air leaks.

The distributing flues in a gas-fired chamber kiln, if trouble is to be avoided, should be built of tongue and groove brick, and should be 9 inches thick. Brick should be dipped and malleted. The arches are particularly important. The gas control valves seat in the bottom of these flues and the valve stems extend up thru the arches by means of small holes. Often these stems "freeze" in the holes thru an accumulation of tar around them. In pulling them loose, the arch key is loosened, which is followed, in time, by loosening of the arch itself to such an extent that it must be rebuilt. This difficulty is entirely overcome by the use of large key blocks instead of key brick (see Fig. No. 4 for details).

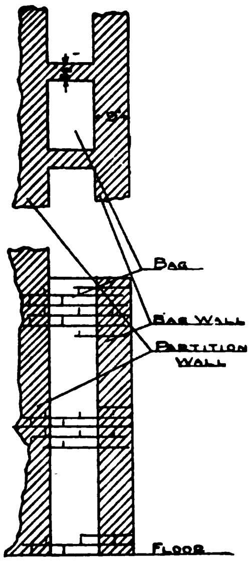


Fig. 3. Bag Wall.

To line a steel tube from 125 to 200 ft. long with 9-in. shapes is an enormous job, and, when finished, is usually a "sorry" job. A mason cannot do good work with small units while sitting down or lying on his stomach, especially by lantern light. When quarter-circle blocks of the correct circumference are used, they can readily be slipped into place without mortar and a good permanent job results (see Fig. No. 5).

Rollers Permit Expansion of Metal Flues.

The expansion of metallic flues is taken care of by means of rollers which allow the flue to work back and forth freely. Special care should be taken at points where these flues make a right angle turn. At such points two sets of rollers with a plate between may be provided to allow the flue to move in both directions. These rollers are laid at right angles to each other as shown in Fig. No. 6. Four 2-in. steel balls, laid between two steel plates, will answer the same purpose.

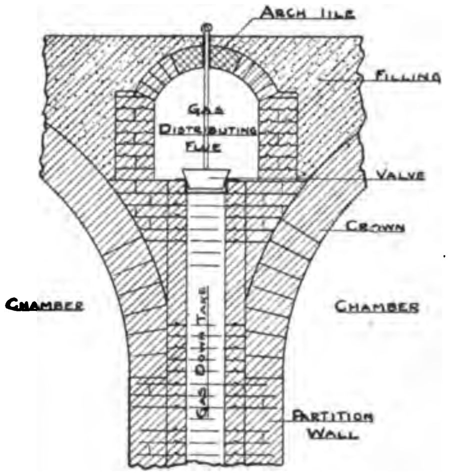


Fig. 4. Section Thru Gas Distributing Flue and Down Take.

When a metallic flue enters a brick flue, provision must be made to take care of the expansion of the former. If the metallic flue is tied into the brick flue it will soon destroy the connection and may damage the surrounding brickwork. When the brick flue continues in same direction as the metallic flue, the latter should extend into the brick flue and be allowed to slide back and forth in it. The joint is then mudded over when necessary. When a horizontal metallic flue is connected to a vertical brick flue, the bottom of the metallic elbow should be built with a wide flange. This flange should simply rest on the walls of the brick flue so that it may slide back and forth freely. In this case also the joint is simply mudded tight when necessary or closed with a sand seal as illustrated in Fig. No. 7.

Build Up-Takes Separate.

When vertical brick flues or "uptakes" are built to convey gas from underground flues to flues in upper part or on top of kiln, they should be made entirely separate from kiln walls. Such flues are often heated to fairly high temperatures, and must be allowed to expand freely; they should be built 18 ins. thick with alternate courses of headers and stretchers. The corners should be fitted with 3-in. angles for the entire height, and these angles should be tied every three feet with ⅞-in. iron rods. The interior 4½ ins. should be of second quality fire brick laid up in a mixture of fire clay and shale, the balance of the wall being laid up in three-to-one Portland cement mortar. The fire brick in the lining should be hard; the joints thin. Producer gas will destroy a flue in a few years unless proper precautions are taken.

Underground flues, with the exception of gas flues, serve the same purpose in both coal- and gas-fired kilns, being generally confined to main draft flues and "cross-over" or "return" flues. Two points must be carefully weighed in constructing these flues: (1) they should be as tight (free from leaks) as brick construction can be made; (2) they must be very strong to carry the loads.

Draft flues may be constructed of common brick. Cross-over or return flues are seldom subjected to temperatures exceeding 1,400 deg. F., and usually common brick with a high melting point will serve for them. A good wall for underground flues (see Fig. No. 8) is 13 ins. thick, with a header and stretcher on each course, the header being reversed on every course, so that it is outside on one and inside on the other. This bond breaks the vertical joints so that none of them go thru the wall. Draft flues should be laid up entirely in three-to-one Portland cement mortar. Heat flues should have inside four inches laid in clay or shale mortar and the outside nine inches in Portland cement. All joints should be as thin as it is possible to make them.

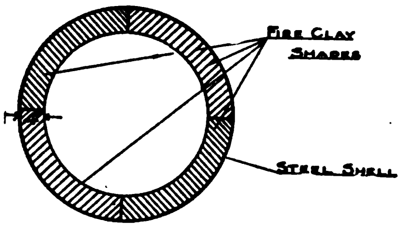


Fig. 5. Method of Lining Gas Flue.

Expansion Joints in Cross-Overs.

Expansion joints should be left every 40 or 50 ft. in all cross-over or return flues over 50 ft. long; otherwise the flues will soon wreck themselves and greatly affect transfer tracks and pavements above them. This also applies to long underground gas flues which expand greatly on being "burned out."

A trench for an underground flue should be only wide enough for the

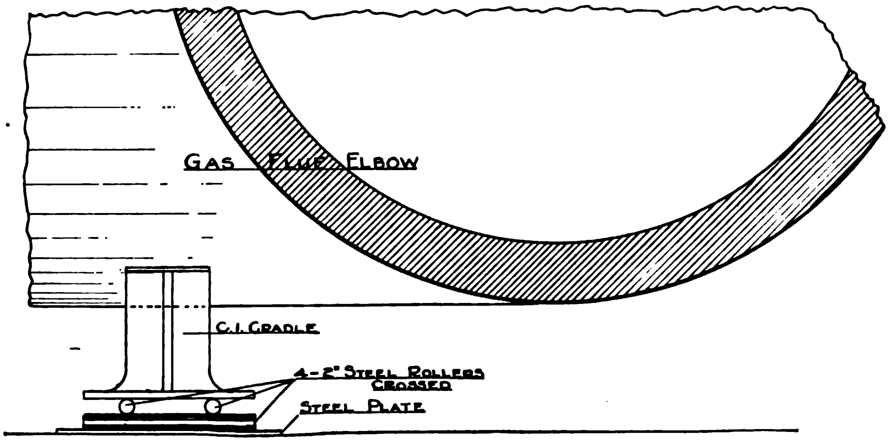


Fig. 6. Method of Taking Care of Expansion in Two Directions at Flue Elbows.

flue to fit snugly. A wide trench, filled in with loose materials, will soon result in a wrecked flue, for as soon as weight is put upon the arch the walls spread and the key of the arch is gone. More continuous kiln trouble results from air leaks in flues and walls than from all other sources combined.

Underground gas flues should be built in the same manner as other underground flues, but should have a double arch, the upper ring being laid in cement mortar. On top of this arch should be laid a covering of sand several inches thick as a seal for the gas.

All underground flues should be completed before the kiln is put up.

Regarding Crown of Kiln.

Experiments have shown that the same rules apply in continuous crown construction as in rectangular downdraft construction, with a height equal to one-third the width of the tunnel or chamber. Such a crown gives good capacity and best burning results.

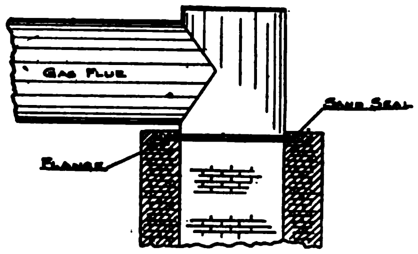


Fig. 7. Elbow on Brick Flue.

The crowns should be built in the most careful manner. The mortar should be fire clay, laid on as thinly as possible with a trowel and each brick malleted down to the course level. If the clayworker insists on dipping his brick, in no other way can he get what he wants except by specifying the allowable variation in size when buying the brick, both straights and shapes. The proper number of wedges and straights should be used to make the arch come up perfectly. The key must fit so tight that it will not go more than half way to its seat when pounded with a hand mallet; it should then be driven home with a wooden block and sledge hammer.

On top of the 9-in. crown a 4½-in. arch should be built; this may be of common brick laid in clay or shale mortar. If the work on this false crown is well done, it will add considerable to the strength and life of the fire brick crown. The spandrels should be brought up solid to the top of the crown.

Expansion Joints in Crown.

Expansion joints two inches wide should be left in the crown every 20 ft. at the same points at which the expansion joints in the lining occur. These joints should extend thru the 9-in. crown only. The 4½-in. false crown should cover the expansion joints in the 9-in. crown, but should have ½-in. expansion joints left in it at other points 20 ft. apart. On top of this joint a rowlock of brick should be laid (see Fig. No. 9). If the expansion joints extend thruout the entire crown and are covered merely with a rowlock, trouble is almost certain to occur within a year or two. The constant movement of the crown shifts the loose brick covering the joints and finally one or more drop into them and wedge them apart, resulting in the shifting of the entire crown. Moreover, as the brick covering shifts, the earth filling begins to work its way into the joints with the same result. At the joints where the false crown covers the expansion joints, fire brick should be used instead of common brick if the temperatures to be attained warrant it.

While a tunnel crown built of 9-in. straights and shapes, with a covering arch of common brick, will give perfect satisfaction when properly constructed, a better but slightly more expensive crown can be built of 13½-in. arch blocks made to order for the required radius. These blocks should be marked by the manufacturer and laid up according to blueprint. Such crowns represent the highest type of construction.

Drop Arches a Source of Trouble.

The best practice calls for an arch 18 ins. deep, and it is rather difficult to build these arches and make them "stay put" with 9-in. straights and shapes. Splendid results have been obtained by the use of large 18-in. fire clay blocks, made to order, the units being as large as possible for convenient handling. If the blocks are hard burned, of perfect fit, and are laid up with a dipped joint, drop-arch troubles will disappear.

When coal-fired chamber kiln crowns are built of 9-in. brick, the same construction rules as for tunnel crowns should be followed, except there is far more reason for the use of the large blocks. In the chamber kiln the chambers are subjected to lineal expansion and to the thrust of the chambers on each side; this thrust has a tendency to "roll" them in the direction of the advance of the fire. Most of the crown deformation has been due to the half-circle design, for it is obvious that the higher the arch the more easily it can be crushed out of shape. The fact that any movement which takes place in the crown must be in the mortar joints, is another reason for using large blocks, as these eliminate a large percentage of the joints.

In coal-fired kilns the feed holes should be constructed of heavy, hard burned blocks made to fit perfectly in the crown. These feed holes are subjected to considerable wear and the use of standard brick will prove a source of continual repair expense.

Gas-Fired Kilns Hard on Crowns.

Experiments have shown that the 9-in. crown will not stand up for any length of time under the conditions to which the gas-fired kiln is subjected; in this case, the 13-in. crown must be built.

In the case of a gas-fired kiln which has fires only on one side of the chamber, there is no question but that a long-lived crown can be built, but this requires that every precaution be taken in regard to design, material and workmanship. Any attempt to cheapen or slight the work will multiply the original cost many times over after a few years of operation.

In setting the forms for a crown, remember that it will settle about one inch after the forms are removed. Due allowance must therefore be made for this settle.

Bracing Crowns Between Chambers.

In the coal-fired and double gas-fired types of chamber kilns it is easy to brick up solidly between each crown, and when this is done it is almost a guarantee against any deformation.

In the case of the one side gas-fired kiln the gas distributing flues should be placed as high as possible and solid brace walls from one crown to another be built up to the bottom of the distributing flues. Any attempt to brace against the distributing flues will result in their being crushed.

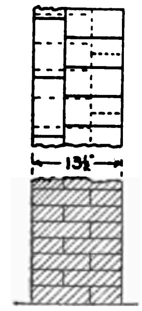


Fig. 8. Flue Wall Construction.

Filling over the tops of the crowns should not be done until the entire battery or kiln is completed. The easiest method of doing this is to hoist a dump car to the top and run tracks the full length of the kiln. The material can then be spread evenly over the entire top. A kiln may be badly damaged by commencing at one end and filling in to the required depth before moving on, as this throws an im-

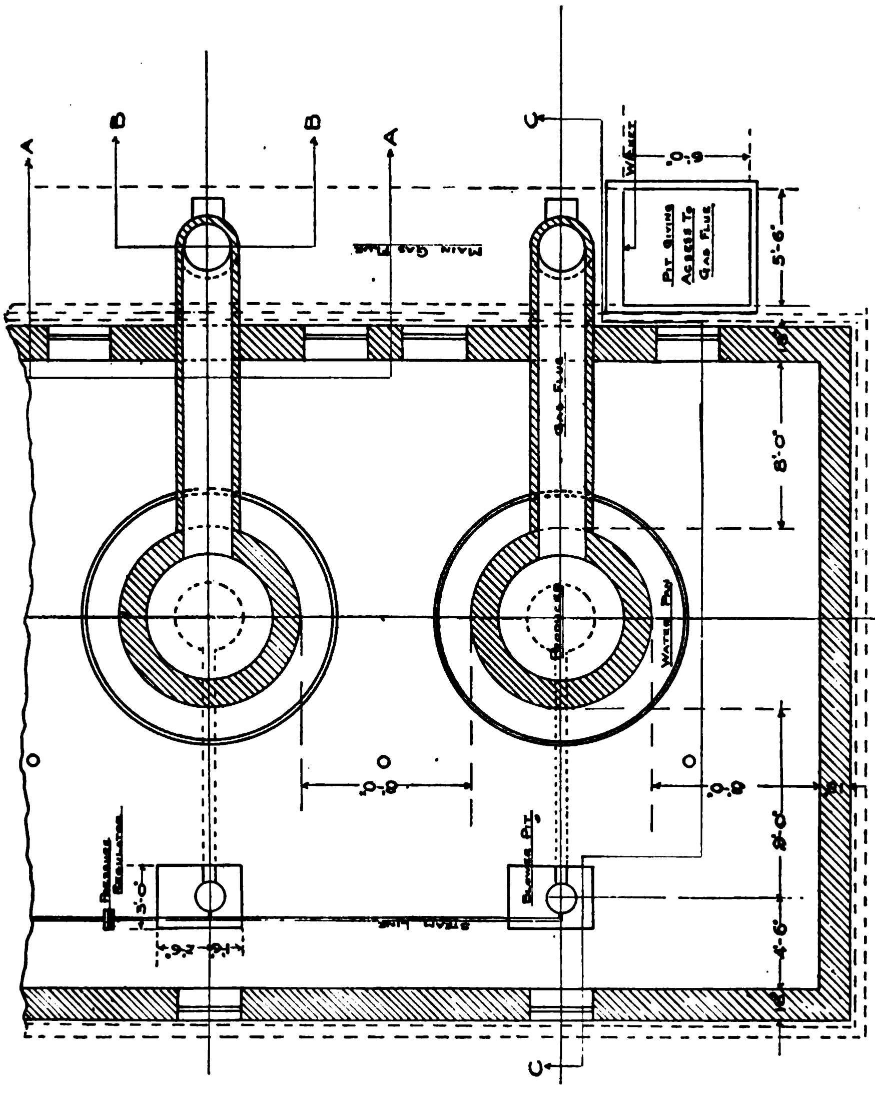


Fig. 1. Plan of Producer House Shown in Elevation on Page 69.

mense weight on one portion of the structure which, in extreme cases, may collapse. This is especially true of the chamber kiln.

Primarily, this filling is intended as an insulator, and the thicker it is, the greater its insulating value. As a rule, this filling should not be less than two feet thick over the highest point of the crown. It may be heavier, if desired. The walls of the kiln must, of course, extend to the level of the top of the filling.

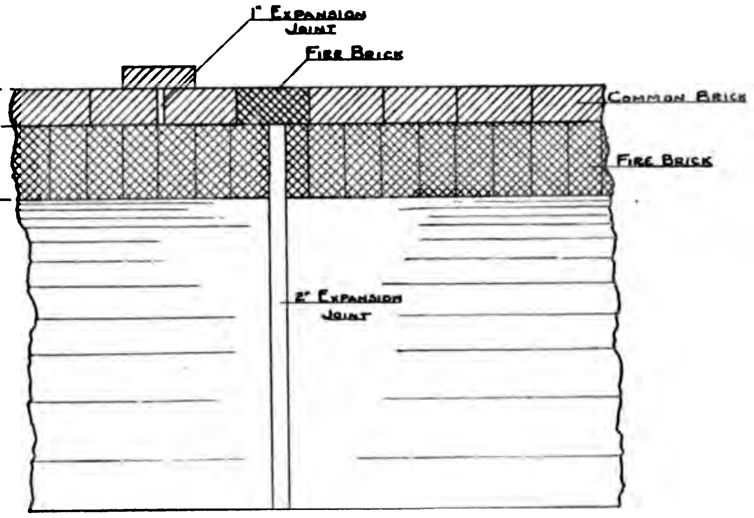


Fig. 9. Section of Crown Showing Expansion Joints.

A covering of six inches of burnt-out ashes next to the crown makes an excellent insulator, when they are available. For the balance of the filling almost any sort of earth may be used.

The platting on top of this filling should not be laid until the kiln has been in use for six months or a year, if a good level floor is desired. The filling is sure to settle and shrink for a long time, and nothing will prevent a poor, unsatisfactory job if the platting is put down at the time the kiln is built.

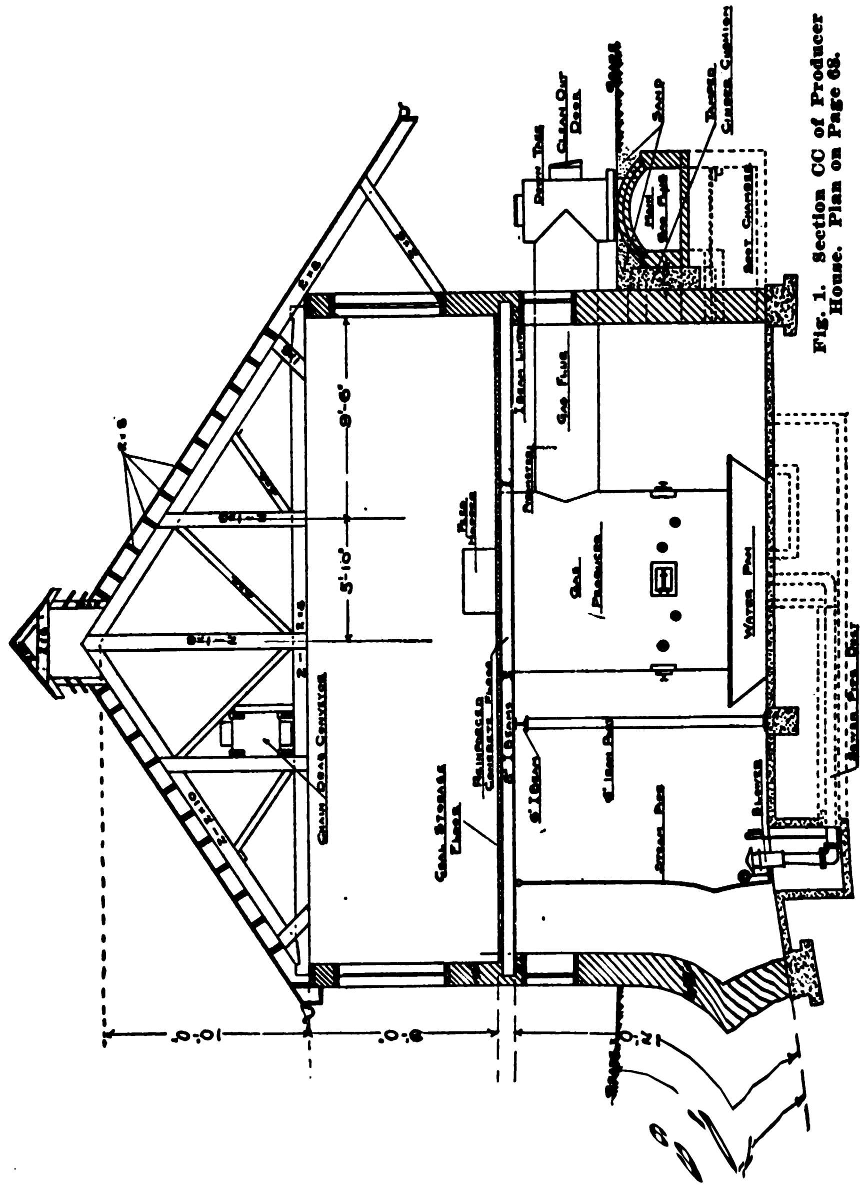


Fig. 1. Section CC of Producer House. Plan on Page 68.

BUILDER (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

382—KILN, CONTINUOUS, DESIGN AND CONSTRUCTION OF PRODUCER HOUSE AND KILN ROOF.—It is not necessary to describe chimney construction, since few clayworkers consider the use of a chimney in connection with a continuous kiln. With a fan, a constant speed can be maintained under all weather conditions, and the "best chimney speed" can also be increased from 50 to 100%. As the conduction and radiation losses on a kiln are practically constant under all operating conditions, this increased speed reduces the proportionate heat loss. Also, with a fan the waste gases can be exhausted at 50 to 75 deg. C. when the kiln has a water-smoking arrangement, while for maximum efficiency the mean temperatures of the gases in a stack must be maintained at 300 deg. C., which really means that the exhaust gases at the base of the stack must be kept at from 400 to 500 deg. C. to allow for cooling as they rise to the outlet. This item in itself is worthy of consideration and assists considerably in overcoming cost of fan operation.

Small, high-speed fans should be avoided; a large unit that can be operated at low speed is more economical. The best type of fan for continuous kiln work is the overhung induced draft or suction type. The fans should always have copper blades and cast-iron arms. Sheet-iron blades and mild steel arms are eaten away so quickly by the gases that they are practically useless. When electric power is available on a steam operated plant, one fan may be motor-driven, and one engine-driven. On electrically driven plants variable speed motors should be used; the control given by such motors makes it unnecessary to handle the dampers in order to regulate the draft. Also, results are more positive when the draft is regulated by fan speed.

The fans should be covered with a brick housing, as a steel housing is soon destroyed by the gases. In building the housing, some means should be provided for examining the fan from time to time and also removing it for repairs.

Even when using a fan, a discharge stack is necessary. Such stacks should be high enough to carry the gases well above the yard. Otherwise, the waste gases drifting thru the yard and buildings will often interfere with the work of the men.

Regarding Roof Construction.

Continuous kiln roofs vary from the flimsiest type of shed structure to high-grade steel construction. Men of experience generally agree that the wooden roof is to be condemned. Its size and weight compels the use of heavy, expensive trusses which have a tendency to weaken under their own weight. It is a bad fire risk, and the rate of insurance (or inability to get insurance) and the upkeep probably make it about as expensive as the steel frame, metal-covered roof.

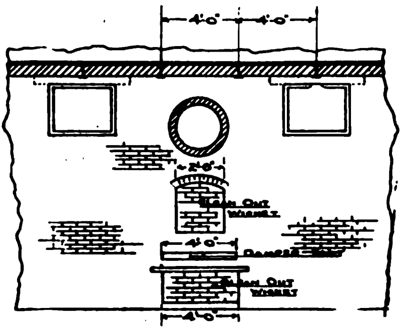
In the case of the double battery kiln, roofs of the double- or triple-hip design should be avoided, since, in addition to large first cost, it is practically impossible to construct them so that water from melting snow and rain will not leak onto the kiln after the roof is a few years old. It is much better to construct the roof with a single ridge, no matter what the span may be.

When wooden roofs are built, keep the trusses high enough above the kiln top to avoid danger of fire; also avoid placing trusses or any timber work near vents in crown or other parts of kiln which become very hot. Exposed gas flues, which get very hot during "burnouts," require watching.

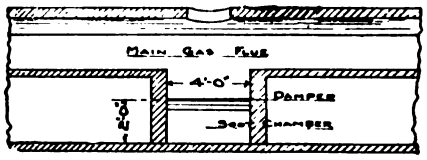
Housing Gas-Producers.

In providing a housing for gas producers for a producer-gas-fired kiln, the building to be erected should be strong, as nearly fireproof as possible, well lighted, well ventilated, and have ample space for working conditions.

The "clean-out" floor should be arranged to leave at least eight feet clear around each producer, to allow room for using long bars for breaking down clinker thru cleaning doors, as the men cannot work too close to the open doors in hot weather. The water pans or seals should be set up on floor like a saucer and not buried so that the rim comes level with the floor. Setting them up makes it easier for the men to pull clinkers from under producer and makes removal of clinker from pans much easier and quicker.



Section A-A



Section B-B

Fig. 2. Soot Chamber. See Plan on Page 68.

Make Blast Pipe Connection Accessible.

A manhole and tunnel should be provided at each producer giving access to blast connection with grate. It is possible for the blast pipe to become choked; consequently, if it is inaccessible, the producer must be shut down and emptied before repairs can be made or else an excavation must be made under the producer.

The blower pits should be in a well lit, accessible location. Each pit should be built so as to allow a man to get down into it and make repairs. All connections between blower and grate which are placed underground and are inaccessible, should be made of sewer pipe. To bury light metal pipes underground leads to troublesome and expensive repairs.

Each blower should be provided with a steam gage and a draft gage, and the main steam line from the boiler should be provided with a regulating valve to insure constant pressure. Each pit should be provided with a steam jet or ejector for keeping the condensation down to the proper level. (The above arrangement is detailed in Fig. No. 1).

Avoiding Shutdowns for Burning Out.

During the operation of a gas plant the greatest accumulation of soot and tar is found in the main gas flue just beneath the point where the "downtakes" from each producer enter this flue. This accumulation chokes off gas supply and occasions frequent shutdowns for burning out. A way of avoiding this trouble by providing a method of cleaning out the flue is shown in Fig. No. 2.

Under each "down-take" is built a chamber, which opens, by means of wickets, into the clean-out floor of the producer house. The accumulated soot and tar falls into the upper part of this chamber onto an iron plate. When sufficient quantity has accumulated to interfere with the gas flow in the flue, the plate is pulled out and the soot and tar falls into the lower part of the chamber. This plate is then replaced and the lower wicket opened for the removal.

The main gas flue should never be tied into or built tight against the wall of the producer house. If it is, the expansion of the flue will either wreck itself or the wall. A cinder cushion between flue and wall will take up the pressure.

All window openings on the clean-out floor should be near the ceiling to allow for the easy escape of gas and heat during the cleaning of the producers.

The floor of the charging room should be fireproof and capable of carrying a load of at least 25 tons for each producer. Since shipments of coal cannot always be regulated, ample storage room to prevent expensive rehandling should be provided. A coal unloading device consisting of a track hopper, elevator and conveyor, which will drop the fuel beside each producer, is an investment worth consideration. Its value will depend upon the size of the plant.

Care should be taken to have the roof of the charging room high enough to allow for the use of the long pokers which are necessary. These pokers are nearly as long as the producers are high, and the roof, at the point above the poke holes, should be somewhat higher than this dimension, especially as the pokers are handled with block and tackle.

A monitor should be built the entire length of the roof to allow for the escape of gas. (See also Gas producer.)

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton, Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

383—KILN, CONTINUOUS, OPERATION OF COAL-FIRED.—Any description of the operation of a continuous kiln of any type can only cover the subject in a general manner. Continuous kilns of the same type, as in the case of down-draft kilns, differ radically in action, each kiln having its own peculiarities. In dealing with a new kiln it must be borne in mind that it takes from five to seven and, in some cases, even more complete rounds before normal operation conditions are reached. This is due to the large body of masonry which must be thoroly dried and heated up, together with the drying out and heating up of the ground under the kiln. The bottoms usually give the most trouble in a new kiln, and it is far more economical to accept soft brick in the bottom courses for the first few rounds than to hold up the kiln and use more fuel in an attempt to make them hard; for not only is the attempt unsuccessful, but brick are overburned at the top, and the kiln acts badly because of the impossibility of holding the "backing" heat for a long period.

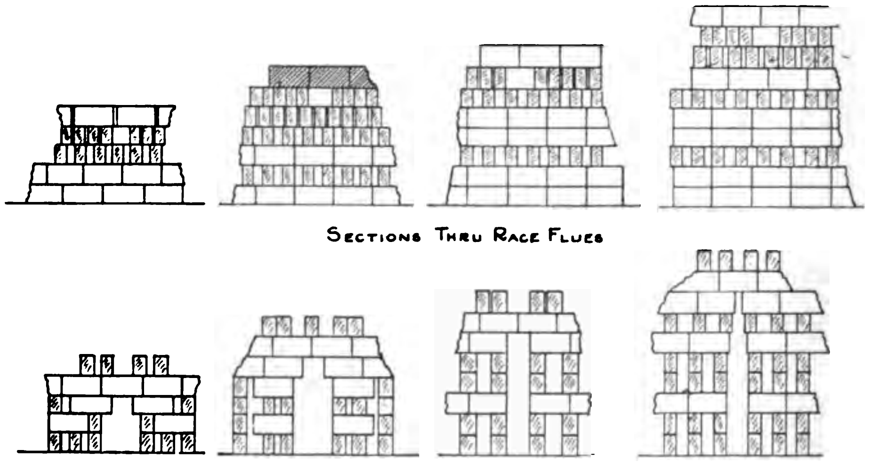


Fig. 1. Method of Setting Race Flues.

Best Fuels for Kilns.

A continuous kiln can be operated on very low-grade fuels, but the best and most economical results cannot be gotten from such fuels. The results obtained from slack, which is high in ash and low in volatile matter, are not to be compared with those obtained from a high-grade, clean slack, and, as a rule, it does not pay to use the former when the latter is available. A high-grade fuel will give a greater burning speed, and much less of it will be required per unit of ware. Where high-grade ware is burned it is decidedly advantageous to use a fuel low in ash. The draft carries the ash and scatters it over the ware, and if there is a large quantity of it, much of the ware may be marred or spoiled.

The setting of the ware in a continuous kiln is, with little question, the most important point in the operation. On it depends to a great extent, not only the speed of burning, but the quality of the resulting ware, and the fuel consumption. Many kilns which would have given good results have been condemned as failures in this department. The setting in this type of kiln differs from all others because the fire and draft moves in the direction of the length of the kiln. In other words, the draft, instead of being up or down, is horizontal.

Being generated, to a great extent, on or near the floor, the heat has a natural tendency to rise to the crown, and this tendency can only be overcome by so arranging the setting that a freer flow is given near the floor, while at the same time the draft is baffled by tighter setting towards the top. These conditions, coupled with the necessity for providing firing or fuel shafts in the settings, and also the necessity for counteracting the pull of the draft connections on one side of the tunnel, make the setting a difficult and intricate problem.

Movable Fire Tunnel Kiln.

This type of kiln is best adapted for burning the commoner grades of ware, in which clear color and flame flash are of little importance. However, it is successfully used for high-grade products. In such cases, special care must be taken to protect the faces or sides to be exposed when in use, from the flame, flying ash and fuel.

Setting plans are usually furnished with a new kiln and a skilled setter often furnished to start the work off right, but as every kiln has its own peculiarities, the standard setting plan is seldom followed, entirely, for any length of time.

Setting Race Flues.

The race flues or trace holes, as the flues running along the floor and parallel to the length of the kiln are called, are variously set from two to eight brick high and are from four to eight inches wide. Their number is governed by the number of feed holes across the tunnel. No standard size can be laid down for these flues, as they are governed by the amount of ash in the fuel, the draft, the kind of ware being burned, the setting above them, and the general conditions under which the kiln is operated. The low, wide flues are recommended, as they do not complicate the setting as much as the high, narrow ones.

Since the tendency of the heat is always to travel faster in the middle race flues, it is sometimes necessary to have the outside flues higher and sometimes wider than those in the center. In kilns with the tunnel continuing around the end, it is necessary to vary the size of these flues making the ones nearest the inner wall the smallest and gradually increasing the size towards the outer wall. This prevents the gases from short-cutting thru the shortest flues as they would do unless forced to take the longer route. Fig. No. 1 shows various methods of setting race flues.

Soft bottoms are due in many cases to the size of race flues. When too large, the cooler air tends to run along the bottom thru these flues, thereby keeping the bottom courses chilled. This difficulty is often overcome by merely reducing the size of these flues. When using coals which are high in ash, care must be taken to provide sufficient height to prevent their becoming choked and thereby preventing sufficient air from reaching the fires ahead.

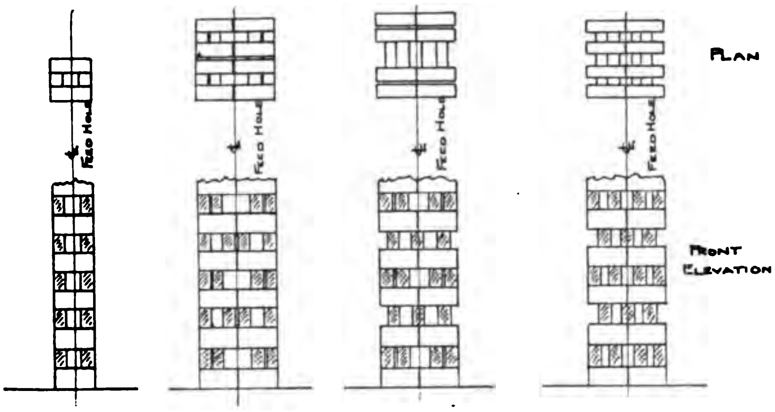


Fig. 2. Method of Setting Firing Shafts.

Guide Helps to Locate Flues.

A guide for locating the race flues should be provided for setters unskilled in continuous kiln work. This guide consists of a board of length equal to the width of the tunnel, with correct location of race flues marked upon it. It is quite important that race flues be kept perfectly straight. Kinks and projecting brick interfere with the draft and make it impossible to standardize the kiln operation.

In determining the best type of fire shaft to use, three factors must be considered: (1) the size of fuel to be used, whether very fine or very coarse slack; (2) the quality of fuel, whether high or low; (3) the kind of ware being burned, whether common and not affected by the flame ash, or high grade and likely to be culled by flashing and ash.

The coarse grades of fuel usually burn faster than the finer grades (unless dust is used), and there is, therefore, less chance of their heaping up and caking and thereby choking the draft in the race flues. They also tend to distribute themselves thru the length of the shaft better than the finer grades. For these reasons it is possible to set much simpler fire shafts when coarse fuels are used (see Fig. No. 2).

Advantage of Non-Caking Fuel.

With non-caking fuel it is possible to allow more of it to drop to bottom of shaft without getting into difficulties with the draft; but when caking coal is used, whether fine or coarse, provision must be made to allow it to lodge at various points in the shaft. With fuels high in ash, and where it is desired to have as little ware as possible spoiled by ash, the shaft must be set so that as few lodging places as possible are provided, but at the same time enough so that the race flues will not become blocked up by the accumulation at the bottom.

When high-grade ware is being burned, and it is necessary to have as little contact as possible between fuel and ware, the condition requires the fuel to be burned at the bottom. Where such practice is not possible, common ware is set around the fire shafts or the ware which is set around the shafts is accepted as common or low-grade.

Combinations of the above conditions occur so frequently that it is usually necessary to experiment until the most suitable method of setting the shafts is found.

Guides for setting the firing shafts are necessary if best results are to be had. These guides are dropped thru feed holes in the crown and extend to the floor. They are removed thru the holes when the shaft is completed. Shafts must always be set so that a clear view of the bottom can be had from the feed hole.

Setting of the benches depends to a considerable extent upon the draft used. The movement of the draft in a horizontal direction always tends to overcome the disposition of the heat to rise from the bottom. Therefore, the stronger or higher the draft, the greater will be concentration of heat near the bottom, and vice versa. This makes it necessary to set the ware tight at the bottom and looser towards the top when high draft is used, in order to baffle the drift of the heat along the bottom and force it to the top. In case a low draft is used, the ware should be set looser at the bottom with a gradual tightening as it approaches the crown. There are, of course, many intermediate stages between the high and low extremes, but in each case the result to strive for is a heat balance over the entire cross-section of the tunnel, in order to get perfect heat distribution. Experiment alone will determine the best method for each kiln.

Set Ware Up to Crown.

In a tunnel kiln the ware should always be set up to the crown; otherwise much of the heat will travel over the ware, with consequent loss of burning efficiency. The drop arches take care of this difficulty after the ware settles and for this reason they should be kept in good condition and the brick set tightly against them.

Two things must be constantly borne in mind: (1) that the heat must be kept ahead in the bottom, and (2) that it does not pay to crowd the ware in a continuous kiln. Setting too close invariably increases the cost thru the slowing up of the fire travel. On the other hand, if the setting is too open, trouble will result from admission of too much air into the fire zone, and thru the premature loss of "backing" heat.

Paper Partitions Placed with Care.

Lack of care in applying the paper partitions at the end of each section often results in poor operation. It is possible to put on a good air-tight partition. Ordinary flour paste will answer the purpose, but it must be kept fairly thick. The paper must be of a kind that will not lose its strength when dampened by the moisture of the water-smoking period, but it must not be too heavy and stiff to make it impossible to paste it to the brick. To prevent rats and mice eating the paper, copper sulphate or other poisons may be dissolved in the paste, as an exterminator.

In tunnel kilns not provided with water-smoking arrangements, and where water-smoking is accomplished by drawing combustion gases thru the last section set, before exhausting them into the draft flue, scumming trouble is practically a certainty. Combustion gases always contain sulphur trioxide and sulphuric acid, and when these are brought into contact with the moist, cool ware, they cause the formation of a scum or "whitewash." To this reason is traced the large amount of discolored and unsightly ware burned in this type of kiln.

When the kiln has no special arrangement for water-smoking, the only precaution necessary at this period is to be sure that the temperature of the gases which are admitted to a freshly set section is not too high; in other words, that the setters are not too close to the fire. With some clays, it is possible to admit gases at temperatures of 200 deg. F. or over; in other cases, it is not safe to use them when over 100 deg. F. at the beginning. This can be regulated by the number of sections ahead of the fire, as the greater the number of sections the gases travel thru the cooler they become.

Water-Smoking Simple with Special Flues.

The water-smoking arrangement consists of connecting the flue to a section behind the fire which has still a temperature of from 200 deg. to 500 deg. F., and then making a connection with the section to be water-smoked. The connection with the main draft flue is then opened and the pure hot air is drawn thru the ware. The paper partitions at each end of the water-smoking section are naturally kept intact until the period is completed. In this way the draft is controlled independently of the sections under fire. In order to control the temperature of the hot air entering the section, provision is made for admission of cold air into the water-smoking flue in any desired quantity.

As kilns are generally designed so as to provide for an advance of one section per day, it is usual to complete the water-smoking in 24 hours. It is seldom possible in this length of time to get the ware above a temperature of 200 to 225 deg. F. thruout, but whatever the temperature may be when the period is up, the partition nearest the fire is broken and the section thus connected up with the burning section. The water-smoking flue connections are then advanced one section at each end.

Water-Smoking Related to Kiln Design

Successful water-smoking in a tunnel depends very largely on kiln design. Some kilns are designed so as to make it almost impossible to get the proper distance of heat in this period. Also, the construction of water-smoking flues may be so bad that sufficient heat cannot be drawn thru them because of air leaks; the result is that the section has to be taken into the circuit before the period is complete, and the ware is always "scummed."

The use of temporary fire boxes built in the wickets is sometimes resorted to in the water-smoking period. These fires are fed with wood, coal or coke, and are made to carry the section as far along as possible, or to augment the heat from the water-smoking flue.

When connecting up a section that has been water-smoking to the sections under fire, it is best to split the draft for a certain period. Instead of closing the connection between the section behind the water-smoked section and the draft flue, and drawing all gases thru the water-smoked section, the draft connections of both sections are partially opened, thus splitting the draft. If gases in burning section are very hot, this method reduces the shock to the ware in the new section. As temperature is raised in this section, however, its draft connection is gradually opened wider while the one in the section behind is gradually closed. This operation is continued until all the draft is taken thru the new section. With some clays such precautions are unnecessary, and in such cases the change may be made abruptly.

Do Not Burn Paper Partition Prematurely.

The gases of the paper burning sections should never be hot enough to burn the paper partition of the water-smoking section until after the water-smoking is completed. If such is the case, the waste gases are being discharged at too high a temperature and the kiln is not being operated economically. When the setting is held up for any reason, the burning must be slowed, and, if necessary, stopped completely. A continuous kiln loses heat very slowly and firing may be stopped for from two to five weeks and there will still remain enough heat to ignite fuel when operations recommence.

Sections to Keep Under Fire.

Concerning the number of sections of a kiln that should be kept under fire, this subject can be covered only in a general way, taking a sort of average of general conditions.

Fuel should be fed to from three to five sections. The high fire section naturally consumes the greatest quantity, and, as a rule, light charges should be fed every 10 to 20 minutes. The feed holes ahead and behind the high fire are fed lighter charges and at wider intervals, according to their distance from the high fire and according to the speed with which the fuel is consumed, and the sort of clay used. Usually a section is under high fire until the finishing heat is reached, top and bottom, and then a soaking heat is maintained for a certain period until the ware is finished. During this period the finishing heat is advanced. The whole operation, of course, is a continuous one, the peak of the temperature curve slowly advancing all the time.

As the fire advances fuel is fed to fresh rows of feed holes, but never until a red heat shows in the bottom, and fuel should only be fed at such times and in such quantities as can be entirely consumed. Premature firing or feeding in too large quantities will result in an accumulation of fuel in the race flues, with consequent checking of the draft, and the possibility of too much local heat when the accumulated fuel does ignite. It is always best to defer feeding fresh holes until a red heat is visible, at the bottom, in daylight.

“Backing” Heat.

It is sometimes necessary to feed fuel to several rows of feed holes behind those which are at finishing heat, in order to maintain what is known as “backing.” A continuous kiln, to work efficiently, must have preheated air for combustion. This preheated air is furnished by passing the air required for combustion thru the ware that has been burned. In this manner two things are accomplished: (1) a large percentage of the heat is recovered and reused and (2) the air reaches the high fire section at a temperature only a little below the temperature required to finish. It is chiefly because of this that a continuous kiln uses only 20 to 35% of the fuel needed on a periodic kiln.

The amount of fuel required to maintain the proper “backing” depends largely upon how close to the fire the unloaders work. If they are very close, thru a desire to rush ware out of kiln, a larger number of rows will have to be kept under fire than would otherwise be necessary. Obviously, there is a limit. The result of working too close is that the cold air rushes along the floor thru the race flues and makes it almost impossible to get the bottom in the high fire section up to the finishing point, thus checking the advance. When the proper number of sections are kept behind the fire it is often possible to stop feeding fuel as soon as the ware has received the proper amount of “soaking,” there being no necessity for maintaining a “backing” fire on account of the hot ware thru which the air must pass.

Wicket fires are used in some kilns to assist the top firing in the high temperature zones. Not only do they increase the burning speed to some extent, but they insure a well-burned wicket, a point usually hard to finish properly in the average continuous kiln. Wicket fires are usually started in the section ahead of the one showing red heat in the bottom. The fires are started slowly and gradually brought up as the ware will stand it. They are maintained until after the section has passed the finishing point, when the grates are withdrawn and the opening bricked up.

Wicket Fires Questioned.

There is some question as to the economy of wicket fires, in spite of the aid they give locally to the ware in the wicket and to the section in general. As with up- and down-draft kilns, a considerable excess of air is certain to pass over the fires. The air is not preheated, as is the air fed to inside fires, and, consequently, there is a loss in efficiency. Consideration must be given to the ware damaged by contact with flame and ash of the fires, there being no bag wall to protect it. To this is added the cost of constructing these wicket fire boxes, and cleaning up the ash and spoiled ware after them.

Draft.

It is practically impossible to designate the number of sections thru which the draft should be pulled to get the best results. Kilns equipped with stacks are definitely limited, as the stack can only pull thru a certain number of sections and maintain any kind of speed. In this case experiments are necessary to determine the maximum number for best results, and the standard thus arrived at should be maintained. When fans are used, the size of fan is an important factor. Often the fan units are too small; this trouble, however, is more easily remedied than where an undersize stack has been built. An oversize fan is a good investment, since it is a simple matter to cut a draft that is too high.

The speed of a continuous kiln is dependent to a large extent upon draft. In kilns of the same type and size, burning practically the same class of ware, the difference in rate of advance may range from 100 to 250 ft. per week. Some of this difference is due to material, but most of it to methods of operation. For example, it is plain that fire will travel at a greater rate thru a tunnel under a high draft than under a low draft; also that fire will travel faster thru a loose setting than thru tight setting, and that the gases can be pulled thru the former at a higher velocity than thru the latter. However, there is a definite limit to the velocity that may be given to the gases in a kiln by the fan or stack. Kiln operators are familiar with the fact that at a certain point in advance of the row of feed holes receiving the finishing heat, there seems to be no draft. When the caps are lifted over this point there seems to be neither suction nor pressure, while ahead there is suction, and behind, over the high fire, there is pressure or “kick.” Some operators have noticed that best results are obtained from a kiln when this point of “no draft” is kept at a certain determined distance ahead of the feed holes receiving the finishing heat. If the draft is increased or decreased, this point will move from its proper place and almost immediately the rate of progress seems to be arrested.

Some years ago Wm. A. Butler, ceramic engineer, discovered that if air is forced by means of a fan thru the cooling ware behind the fires, the draft could be increased and the point “no draft” still maintained in its proper position. Such a condition allows of greater fuel consumption with a more rapid advance of fires. The idea is fundamentally sound. The draft unit is constantly attempting to create a vacuum in the kiln, while nature is attempting to fill this vacuum by supplying air from behind. Unless some mechanical assistance is given to this flow of air in order to push it to its destination (the fires) in larger quantities, the kiln speed will be governed by the speed with which the air can naturally work its way thru the closely set ware.

Learn Point of “No Draft.”

Attention should be given this important point of “no draft.” Close observation of a kiln for a few rounds will determine its proper location (which will vary in each kiln), and once it is found it should be maintained. Draft gages are a valuable aid to the burner, but when not provided, he can soon learn to control the draft by noting with his hand the distance above the feed holes, in the finishing zone, to which the hot air is forced.

After the finishing heat has been reached in a section it is a general rule to maintain the fires for a sufficient time to give the ware a “soaking.” This “soaking” fire is usually maintained over an entire section at least, the fuel being fed in such quantities and at such intervals as will maintain a fairly constant temperature. The heat generated in this section both improves the quality of the ware and furnishes “backing” for the high fire section by increasing the temperature of the air of combustion. There is no waste of fuel in this practice because the amount used on the fires ahead is decreased in proportion.

Position of Unloaders.

Every effort should be made to keep a red heat in at least three sections behind the finishing fire. This is not difficult if the unloading section is kept far enough behind the fire. Opening sections too close to the fire decreases the efficiency of a kiln and results in numerous troubles. Sometimes the ware is cooled too quickly, resulting in cracked, checked or brittle products.

No rule can be made regarding the number of sections to be carried in a circuit, but roughly it should be as many as can be handled and still get the proper draft. It is useless to connect more sections than the fan or stack can handle properly, for under such conditions the capacity is bound to be reduced.

MANUFACTURERS OF EQUIPMENT
(see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

384—KILN, CONTINUOUS, OPERATION OF GAS-FIRED.—There is little question but that the producer-gas-fired kiln is the most simple and easily operated type of kiln, once the operator grasps the basic principles of operation and gets thoroly acquainted with his kiln; but it is practically impossible for green, untrained men to take hold of this kiln and make a success of it. As with coal-fired continuous kilns there are certain “standard” burning rules which must be used as a basis for starting a new kiln, but as each kiln develops its own peculiarities these rules must be changed to meet the special conditions. Gas kilns probably take longer to get into normal working order than do other types, altho this is not a general rule. Besides the heating up of the masonry and ground under the kiln, which takes several rounds, there is the necessity of training men for work on the producers. The difficulty involved in the latter depends to some extent on the fuel used and the intelligence of the men.

Gas Manufacture.

The success of the gas kiln depends largely upon the operation of producers. The pressure producer is not ordinarily difficult to handle, but this rests largely on the kind of coal available. Unless producers are especially designed for the use of slack, this fuel cannot be used; nut, run-of-mine and lump coal are satisfactory, the nut giving best results when it can be obtained. When run-of-mine or lump are used the large lumps must be broken up, while run-of-mine containing much slack must be avoided.

The chief requirements of a coal for producer work are that it be high in volatile matter and low in ash and sulphur, which means that it must be nonclinkering. To be high in volatile matter, however, is not enough. Many coals have a fairly high volatility but give it off with a rush, thus flooding the kiln with gas for a few minutes, following which the supply is poor. The ideal coal gives off its volatile matter slowly, keeping up a steady supply from this source while the CO is coming from the fixed carbon. Coals high in fixed carbon and low in volatility can be used successfully, but such coals are consumed slowly, or, in other words, produce their gas slowly. The result is that greater producer capacity is required to keep up the gas supply.

Clinker is the great enemy of gas producers and if there is any possibility of avoiding a clinkering coal, this should be done. If not, success can only be had with producers designed by experts expressly for the fuel in hand.

Selection of Coal.

There are many ideal producer coals in different parts of the country and experiments should be made until the best one has been located. Analysis of coal tells very little about its adaptability, but it will give an idea as to whether the coal is worth trying or not. By experiment it has been learned that with two coals having nearly the same analysis, one will be almost twice as efficient as the other. When looking for a producer coal it is a safe plan to consult the manager of the nearest domestic gas plant. Such a plant uses the highest grades of gas coal, and will have information as to its source of supply. Usually, it is well to pay 25 to 35% above the local market price in order to obtain a high-grade coal; the added efficiency of the gas and the lowered cost of labor required to handle the producers will more than save the difference.

Special producers are designed for use with peat, lignite, anthracite and low-grade bituminous coals. In fact, any kind of fuel may be used, provided the producer is designed for it.

Feeding the Producer.

The rate of feeding coal into the producer depends upon its size or capacity, and the fuel. A 6-ft. producer working under easy conditions with a good coal will consume from 160 to 200 lbs. per hour. There is a certain height in each producer at which the top of the fuel bed should be kept. This is usually slightly below the outlet flue. Naturally, fuel cannot be fed faster than it is consumed or it will rise above its proper level, which is the gage that regulates the rate of feeding.

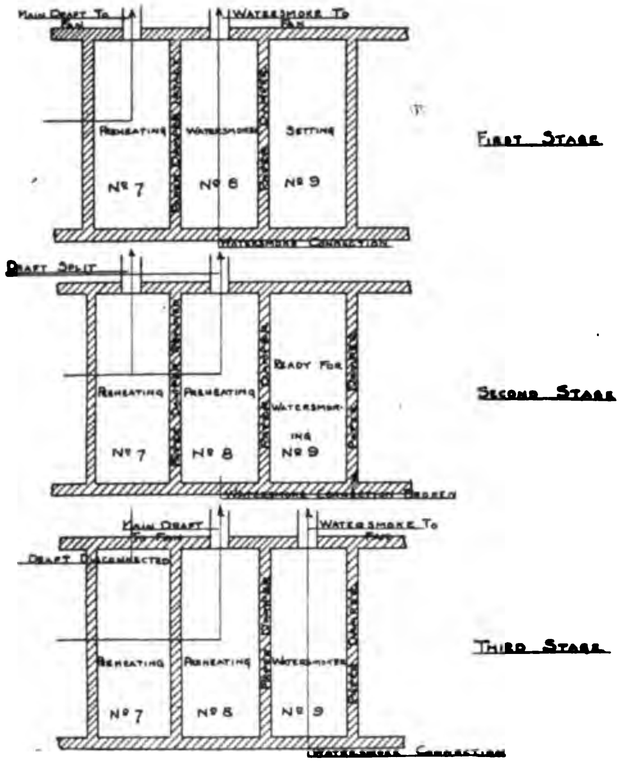


Fig. 1. Diagram Showing Method of Advancing the Heat.

Pokering is an important factor. The pokers should be long enough to reach the grates and the pokering be done in such a way as to "stir" and affect the entire bed from top to bottom. The idea is to break up any clinker over the grate that may prevent the proper distribution of the air blast and to loosen up the fuel so that the air distributes itself thru it evenly, thus preventing the formation of holes or channels thru the fuel bed. The amount of pokering necessary depends entirely upon the kind of fuel used. Sometimes it must be done every hour. At other times, every three or four hours is sufficient. The producer man should watch the surface of the fuel bed for "holes" or bright spots which show that the air is "channeling," and, when one is noted, the poker should be used at once to fill it up.

Pressure at Blower.

The steam pressure at the blower should be kept at 60 lbs. when the producer is operating normally. It is important that the pressure be kept constant under ordinary conditions and that it be not allowed to fluctuate with the boiler pressure. The only safe method of handling this problem is to install a regulating valve in the steam line between boiler and blowers. This will insure constant pressure.

For best results, the air blast from the blower should indicate from 1½ ins. to 2 ins. of water on a U-tube, altho when an increased volume of gas is required it is necessary to run it higher.

The gas pressure in the producer necks should register about ⅜ in. on the U-tube. Maintaining a much greater pressure than this is likely to result in the gas forcing its way out of the gas flues at every crack on its way from producer to kiln. When the pressure drops close to the zero mark a dangerous condition exists, especially if the gas is hot. Good producer gas is highly explosive when at certain temperatures and when mixed with air. As long as pressure is kept on the gas, no air can be drawn into the flues; but when there is no pressure and the kiln is creating a suction, air may be drawn into the flues, and, if conditions are right, a serious explosion will result. Several kilns have been badly damaged thru explosions caused by such conditions.

Gas Temperature Important.

The temperature of gas as it leaves producers is very important. One of the chief troubles producer gas users have met with is due to the fact that the gas "cracks" at certain temperatures and rapidly deposits either soot or tar in the gas conveyors or flues. This soot and tar chokes the flues and shuts off the supply at the burners, thus necessitating frequent "burnouts," as the process of igniting and burning out the deposit is called. The time consumed by these "burnouts" is a dead loss, since the kiln must be shut down for that period, covering from three to six hours.

There are producers designed to overcome this trouble, or scrubbers can be installed for the same purpose, but, as only the simple forms of producers are used on clay plants, and since scrubbers are expensive and unnecessary, the only method left to the clayworker is temperature control.

Producer gas made in the type of producer generally used will deposit tar at temperature below 800 deg. F., and will deposit soot at temperatures above 900 deg. F. These temperatures refer to the gas as it leaves the producers. Thus, there is a neutral zone between 800 deg. and 900 deg. F., and when the gas is kept within this zone, the minimum amount of tar and soot will be deposited.

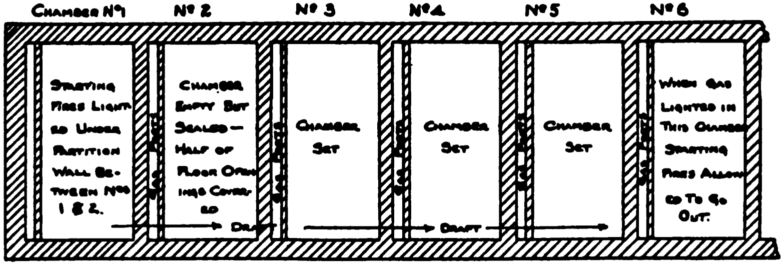

Chamber Nº 1
Nº 2
Nº 3
Nº 4
Nº 5
Nº 6
Starting Fires Lighted Under Partition Wall Between Nºs 1 & 2.
Chamber Empty But Sealed — Half of Floor Openings Covered
Chamber Set
Chamber Set
Chamber Set
When Gas Lighted in This Chamber Starting Fires Allowed To Go Out.
Draft
Draft

Fig. 2. Diagram Showing Method of Starting Gas Kiln.

Coal Has No-Deposit Temperature.

Experiments seem to show that each coal has a definite temperature at which there is practically no deposit, altho all coals experimented with remained within above temperature range. By closely watching pyrometers installed in the gas necks it has been possible to operate a kiln for 59 days before being troubled with choked flues; and by the simple method of keeping the gas at proper color, it was possible to run without interruption for from 30 to 40 days. As the average kiln requires burning out every seven to ten days, the importance of watching the gas temperature is evident.

It is better to keep the gas too cool than too hot. Tar is troublesome at the valves, but takes up very little space in the flues and accumulates slowly. On the other hand, soot accumulates rapidly and soon causes trouble. Also, a high producer temperature means a reduction in the quantity of gas, for it is the burning of the gas, or ingredients that make up the gas, that produces the high temperature.

When the gas temperature is between 800 and 900 deg. F., the gas has a rich yellow color, tinged with light green, and if held at this color cannot be far from its most efficient state. Hot gas is nearly colorless, except that some smoke is seen in it; when very hot, it appears as nearly all smoke. Such gas is nearly worthless except for its sensible heat.

When gas is at its best it will not ignite at the poke holes when a match is applied to it. As the temperature increases, however, it will ignite readily and will finally reach a stage where it will issue as flame instead of gas.

Cleaning a Producer.

A great deal depends upon the amount of clinker or ash the coal produces, but in any case it is unnecessary to clean as often as every day. In some cases all of the clinker is pulled out from beneath the producers thru the water pans, but it is easier and quicker to remove all possible thru the clean-out doors and then with a bar punch the remaining clinker to the bottom where it is then pulled out thru the pans. Two rows of sight holes are provided on most producers. Sufficient clinker should be removed so that the fire may be seen thru the lower row and, when the clinker bed grows sufficiently thick to cover the upper row, it is time to clean again.

When producers are started it is best to dump in enough ashes to cover the grates. A wood fire is then started and coal fed as rapidly as it will ignite, until the proper fuel bed level is reached. The blowers are then started and run for a few hours until the gas begins to have the proper appearance. During this time the products of combustion are let out thru the clean-out doors in the gas necks.

When feeding gas to a kiln which is just being started it is always best to have the gas quite hot, that is, from 1,100 to 1,200 deg. F. Such gas will ignite readily, while cool, rich gas may cause an explosion, with serious consequences. It is never safe to attempt to light gas in a continuous kiln chamber unless red heat can be plainly seen. This can be done by one who has become expert in the handling of gas, but even under such circumstances, kilns have been badly damaged by explosions, the cause of which were unknown.

Burning Out Flues.

This is a comparatively simple matter. Kilns of late design are equipped with flues which connect the fan with the gas flues. The older kilns have "burn-out" stacks, which provide draft for the same purpose. When stacks are used the process is a slow one, consuming considerable time. When the flues can be connected with the fan, the soot and tar are consumed quickly. To start the deposit burning it is only necessary to open the wicket in the main gas flue near the producers and start the draft. The temperature in the flues is sufficient to ignite the soot and tar. In order to burn out the distributing flues, the gas valves on the chambers that are still red are opened slightly as is also one or two of the gas ports. This pulls the heat from the chambers thru the distributing flues and burns the deposit. Care must be taken not to let the temperature in these flues become too high or the iron gas valves will be damaged. Simply closing the main gas valve stops the fire in these flues. If they are not allowed to burn clean at the first attempt, they should be allowed to cool somewhat and the operation then repeated. Only those distributing flues which are at red heat can be burned out in this way, but as a different set of chambers are in this condition at each burn-out period, they all receive attention in time.

It is easy to determine when the flues have been burned clean. While the deposit is burning a thick smoke issues from the fan stack. When this ceases the flues can be assumed to be clean.

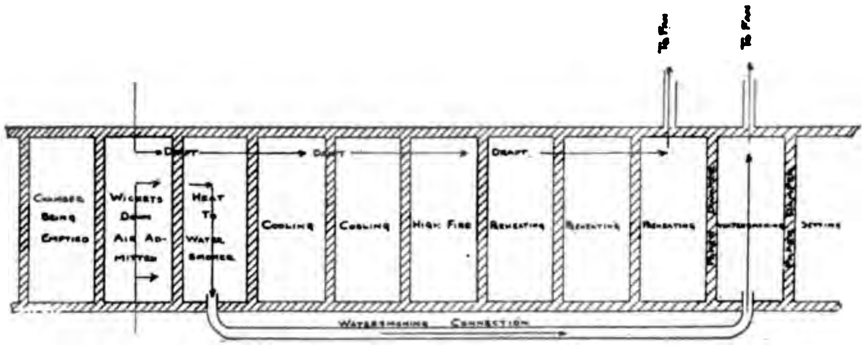


Fig. 3. Diagram Showing Burning Circuit of Gas Kiln.

Setting.

Any method which is used in a down-draft kiln can be followed successfully in setting a continuous kiln chamber. This applies to brick, hollow ware or other ware. In the one-side fire type there is sometimes a tendency on the part of the gas to pull to the side of the chamber opposite the flash wall, but more often the tendency is to short cut to the floor close to the flash wall. In the former case it is necessary to tighten the setting against the partition wall and open it somewhat toward the flash wall. In the latter case the method is reversed and the setting made tight against the flash wall.

In most gas kilns it has been found best to allow plenty of room between setting and crown if speed is desired. Experiments must be made with each kiln to find out at what height the greatest kiln speed can be attained. Past experiments seem to show that after passing a certain height it becomes difficult to reach the bottoms; this, of course, slows the kiln on account of the extra time consumed in getting the bottom ware to the finishing point. On the other hand, it has been found that to set lower than a certain level does not increase the kiln speed at all. Naturally, the material used and ware produced have much to do with the results. When raw material has a very wide burning range and there can be a wide difference between the temperature, top and bottom, without injury to the job, the ware can be set higher without decreasing the speed. Also when fairly soft ware can be disposed of, it is not necessary to spend so much time in getting the bottom to somewhere near the same temperature as the top.

Water-Smoking.

Chamber kilns are equipped with water-smoking flues and, on account of their down-draft design, water-smoking can be efficiently done. The chamber from which the heated air is to be drawn should be selected, not because of its location behind the fire, but on account of its temperature. Generally, the connection to the water-smoking flue is made with the chamber ahead of the last one broken into. The heat from this is drawn into the chamber to be water-smoked until the temperature of the latter is as high as it is possible to get it. The connection with the warm chamber is then broken and advanced to the chamber ahead, the temperature of which naturally is higher. The heat from this chamber brings the temperature of the water-smoking chamber still higher and, as a rule, is sufficient to finish this period. This practice is hardly necessary except in cases of clays which scum easily. When efflorescence is not feared it is the usual practice to get what heat is possible from one chamber and then to connect the water-smoking chamber with the main burning circuit.

The water-smoking chamber is isolated by means of paper partitions over its own bag wall openings and those of the chamber ahead, which is being set. Great care should be taken to have these partitions properly pasted on or draft troubles are sure to occur. When all connections are made with the water-smoking flue, the connection between the chamber to be water-smoked and main draft flue is made. This in no way interferes with the draft or operation of the burning section. The water-smoking chamber is as independent as if it were a single down-draft kiln.

When the water-smoking is completed a hook is inserted thru sight holes at each end of chamber and the paper partitions torn. The draft is then "split," part being taken thru the water-smoking chamber and part thru the chamber behind. This is accomplished by allowing both connections with the main draft flue to remain open and partially closing the dampers on each one. The effect of this is to reduce the shock of the hot gases from the burning section on the water-smoked ware. As the temperature in the new unit increases, its damper is opened wider, while the one behind is closed to the same extent. This is carried on until all of the draft is being taken thru the new unit, at which time the connection with the chamber behind is broken. This process of connecting up a new unit will take from 4 to 12 hours, according to the raw material. (See Fig. No. 1 for diagram of this process.)

It is only necessary to tear the paper partitions at each end of a chamber as the draft will then tear off the balance at once.

Starting a Gas Kiln.

Starting a gas kiln is not difficult. As soon as two or three chambers of ware have been set, about half of the floor openings in the chamber directly behind should be covered with brick. The wickets of this chamber should then be put up and mudded over. In the chamber behind this empty chamber, or the second kiln behind the first chamber set, a few of the floor tile should be taken up so that fires may be started directly beneath the bags of the chamber ahead. Fires are then started beneath these bags with wood and coal, preferably slack. Connection is then made between the main draft flue and the last chamber set, as shown (see Fig. No. 2).

The fires are kept up until the bag walls of the empty chamber and the crown just above are at a red heat, when the gas is turned into it. Burning gas in the empty chamber soon brings the wall and floor to a red heat and naturally very soon heats up the bag walls of the chamber ahead, which is full of ware.

Considerable care is necessary during this period. The air control for the gas burning in the empty chamber, and, later, in the chambers ahead, is thru the coal fires which are still kept burning in the under-flues. If these fires are allowed to get too low or are kept too open so that too much cold air is admitted to the gas, the flame will go out and the conditions may be right for an explosion. It is very easy to tell by the appearance of the gas when conditions are not right. It will burn brightly when the air control is right and become dark and smoky when it is wrong. It should be remembered, too, that these coal fires must furnish the preheated air necessary for proper combustion until several chambers of ware have been finished. To let the fires out after the first chamber has been finished would cause this chamber to lose its heat at once and this would prevent the proper finishing of the next chamber of ware. It is best practice to wait until the fourth full chamber is ready to light before allowing the coal fires to die out.

The principal reasons for having an empty chamber between coal fires and the first chamber are (1) that the heat becomes somewhat tempered in passing thru the empty chamber, and, therefore, does not shock the ware, and (2) that it is much easier to keep the gas lit in the empty chamber than it would be in a full chamber, because of the bulk of ware it is necessary to heat up before a dull red color is reached around the bags.

Burning.

As a rule gas is kept only on the high fire chamber, altho sometimes it is lit in the one ahead of the high fire chamber before the latter is finished. Rarely is the gas kept on a chamber after it is finished, since, in a properly operated kiln, this is absolutely unnecessary.

The conditions in a chamber when it is ready for gas vary with the raw material, kind of ware, and kiln operation. When a chamber finishes around 2,000 deg. F. the chamber ahead will have a temperature of from 1,100 to 1,500 deg. F. It is only necessary to open the valve connecting the main gas flue with the distributing flue and then the valves in the "down-takes" leading to the gas ports. As soon as these valves are opened the gas ignites and the chamber is under fire. The main valve on the finished chamber is then closed.

In the gas kiln the center of the chamber has a strong tendency to get ahead of the ends. It is possible to correct this by cutting down the gas supply at the middle ports, but this naturally slows up the burning. The best method of overcoming this difficulty, and at the same time to maintain or even increase the burning speed, is to light up the two ports in each end of the chamber several hours before the high fire chamber is finished. This gives the ends a start over the center which will not be more than equalized until the chamber is about finished, even with the center ports going at top pressure.

"Led Ahead" Gas.

When the kiln cannot be kept up to capacity of factory with only one chamber on fire at a time, the gas is often "led ahead." In this case the gas is lit in the chamber ahead of the high fire chamber, from 6 to 12 hours before the latter is finished. This keeps gas on two chambers. In this manner the chamber ahead of the high fire gets the waste heat from the high fire chamber and also the heat from its own fires, thus materially increasing the burning speed. This, of course, is possible only where producer capacity is sufficient to supply both chambers.

Perfect control can be had in a gas kiln thru proper handling of valves. There is no excuse for fluctuation in the temperature of a chamber from one end to the other. The sight holes above the bags at each end of chambers provide ample means of detecting any variations in temperature almost instantly, and manipulation of the valve cords provides easy correction.

Unceasing attention must be given the valves. Tar and soot are constantly accumulating between valves and their seats, diminishing gas flow, especially when valves are only "cracked," as the slight opening is easily choked up. Sometimes only one or two valves will "tar up" and the gas that cannot flow thru them is forced thru the other valves. This will cause local hot and cool spots in front of the affected parts. To clear choked-up valves it is merely necessary to shake them slightly by pulling the cords.

Nine Chambers Average to Carry.

The number of chambers to be carried in a circuit varies with size of fan unit, setting and condition of kiln. A fair average would be nine chambers. One of these would be on fire, three ahead would be preheating with waste gases from fire, while the fourth ahead would be water-smoking. Three chambers behind fire would be preheating the air for combustion, and the fourth be supplying hot air for chamber being water-smoked; the fifth behind the fire would be opened to admit the air to be preheated for combustion. This plan might be varied by increasing the number of chambers ahead of and behind the fires; but it would be bad practice to carry less than three ahead and three behind, exclusive of the water-smoking chamber and the chamber supplying it with heat (see Fig. No. 3).

To considerable extent, the number of chambers ahead of high fire should be regulated by temperature of waste gases as they are exhausted to draft flue. On some kilns that are giving excellent results the temperature of exhaust gases is seldom allowed to get above 80 or 100 deg. F.

Question of Draft.

The amount of draft to be carried on a gas kiln will vary somewhat according to construction. In poorly built kilns it is impossible to get sufficient draft to insure a high burning speed, due to great number of air leaks between the fan and the fire. Up to a certain point the higher the draft used the better the burning speed will be.

Under normal conditions a kiln which finishes a chamber every 24 to 36 hours should have 1½ ins. of draft on the chamber ahead of the high fire chamber, and 2 ins. on the second chamber ahead of the high fire. These draft readings refer to conditions just after a fresh chamber has been lighted up. Normally, the draft will show a reduction of approximately one-half inch between the time a chamber is lighted up and finished. Thus, on a chamber which has a 2-in. reading when a fresh chamber is lighted, the reading will be 1½ ins. when chamber is finished.

An expert burner, in addition to using his draft gages, is governed by the sharpness of the flame as it leaves the ports. Under high draft the flame cuts sharply away from the ports; under low draft it rolls slowly under the crown. A record should be kept on each chamber and as soon as the best draft has been determined, it should be adhered to as closely as possible when that particular chamber is reached in the circuit.

Flashed Ware Easily Obtained.

In ordinary burning the gas kiln will produce oxidizing conditions, but reducing conditions can be obtained easily. Flashed ware will not occur accidentally, but may be readily obtained if wanted. However, as with all continuous kilns, it is hard to get any quantity of blacks or very dark colors. This is due to the fact that, while these colors can be easily given to the ware when it is under fire, as soon as it is off fire the ware is reoxidized by passing over it the air necessary for combustion in the chambers ahead. Under the continuous system it is impossible to avoid this. Some clays do not easily lose the flash and in such cases the dark colors are obtainable. Ordinarily, the colors predominating where flashed ware is made, are browns, purples, dark reds, and combinations of these colors.

The method of flashing is simple. When finishing point of ware is approached, the draft is cut very low. This causes the gas to smoke and the chamber is quickly filled. The chamber is allowed to remain in this condition for from 15 to 45 minutes and the draft is then raised and the chamber cleaned of smoke. The smoking is repeated with intervals of 15 to 30 minutes and continued until the colors are reached from top to bottom. Some experimenting is necessary to determine just how long it is necessary to continue the smoking periods. Some clays take the required color in one period of 45 minutes; others require the process to be kept up for 10 or 12 hours.

Care must be exercised during reducing periods or the top course will get too hot and be deformed or melted. For this reason, the chamber is cleared occasionally. The draft being increased carries the heat from top to bottom, thus equalizing temperature of chamber preparatory to another reducing period.

It must be remembered, when attempting to get flashed ware, that conditions in a gas kiln differ from those occurring in other types. In order to get the chambers off quickly, and preserve normal conditions ahead and behind, it is necessary to carry the chambers along almost to the finishing point under normal conditions, leaving the reducing periods to a few hours near the finish. Also the entire firing period is only about 24 hours, instead of from five to ten days as in a down-draft kiln or three to four days in a coal-fired continuous. With clays that are likely to "black core," any attempt to reduce a chamber over the entire firing period will cause trouble, thru the effects on the ware in the chambers ahead. This ware is passing thru the oxidation period while the chamber on fire is being "brought up" and, as all gases from firing chamber pass thru the chambers ahead, it is necessary that these gases be oxidizing and not reducing.

Importance of Backing Heat.

A great deal of the success of the gas kiln depends on keeping the proper amount of backing heat, or, in other words, maintaining proper temperature in chambers behind the fire. Emptying chambers too close up to the fire always causes trouble and lowers efficiency of kiln. Generally speaking, at least four closed chambers should be kept behind the chamber on fire, the air being admitted at the fifth. Another working rule is to keep enough chambers behind the fire so that the chamber which was last taken off fire does not lose more than half its temperature in the first 24 hours. Thus, if a chamber is finished at 2,000 deg. F., 24 hours after it is taken off it should not be less than 1,000 deg. F. A kiln should always give best results if such a condition is maintained.

Fifteen Chambers Best.

Some kilns have been condemned as failures when the trouble was entirely due to the fact that there were too few chambers to maintain continuous operations. When a chamber holds a day's run and can be burned off in 24 hours the kilns should not have less than 13 chambers. This allows for ten in the burning circuit, one setting, and two being emptied. Such a kiln allows practically no leeway and, to be operated without interfering with the factory, must run like clockwork. Sundays, holidays and factory delays would have to be taken full advantage of in operating such a kiln.

It is best to provide at least 15 chambers for good working conditions and to guard against emergencies.

MANUFACTURERS OF EQUIPMENT (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
International Clay Machinery Company, Dayton, Ohio. Continuous producer gas fired kilns either of compartment or moving fire tunnel type. Data on coal saving possible thru the use of this kiln gladly furnished.

384A—KILN CRANE.—This machine or contrivance is an aid to the setting of large drain tile and sewer pipe. The ware is brought into the kiln on sewer pipe barrows, picked up by the kiln crane and set in place by the men without any lifting by the setters. The result is that the ware is chipped very much less than when set by hand.

The crane consists of a pole fastened at the floor of the kiln and also thru the center hole in the crown. Onto this pole is fastened a swinging arm that has straps or bands for fitting around the ware and taking it off of the pallet. The arm swings around so that the ware can be placed wherever desired.

In order to use the crane up to the last part of the kiln, the ware is set so that at the last finally a small segment of the floor from the center to the door is not covered. This part of the kiln is filled last with smaller pieces of ware that can be lifted into place by the men.

MANUFACTURER (see catalog section):
Stevenson Co.

385—KILN, DECORATIVE, see Kiln, continuous, decorating; Kiln, intermittent, muffle down-draft; Kiln, intermittent rectangular, down-draft; Kiln, intermittent round, down-draft; Kiln, intermittent, up-draft, permanent types of, for potteries.

386—KILN, DOWN-DRAFT; DESIGN AND CONSTRUCTION.—Certain unbreakable rules govern the design and construction of all kilns, and if these rules are disregarded, an uneconomical, wasteful, generally unsatisfactory unit is certain to result. A kiln may be economically deficient in many respects: its first cost may have been excessive; it may produce a high percentage of defective ware; it may require high upkeep, which means not only repairs, but loss while out of commission; it may use more fuel than necessary, or require several days longer to burn than it should; it may require rebuilding before it has had a proper span of life. Yet all these defects could have been avoided by proper design and construction at a reasonable cost. It is often claimed that a kiln which will work successfully on one kind of clay and one class of ware will fail on others, and that different conditions have made necessary the highly diversified types of special kilns of down-draft construction. This may be true in one case in a hundred, but not more. The fact is apparent on plants where several kilns of different design are in operation, with some giving better results than others; invariably, the "good" kilns may be nearly correct in principle, while the "poor" kilns are not.

Too Long a Burning Period.

It is generally conceded that most clayworkers take too much time in burning their ware. Most of this time is lost in the water-smoking and oxidizing periods, and in many cases is due rather to poor burning methods than to incorrect kiln design. Upon good authority it is assumed that 90% of shales and clays on this continent can be burned off in six days or less, irrespective of the ware produced; this time includes the entire burning period, from lighting the fires to finish of burn. No exception is made in cases where ordinary carbonaceous shales are used; in fact, where the carbon content of the shale or clay is low, this period, in the average case, should be shortened. Proof of this contention is found in the fact that whenever continuous kilns have replaced down-draft kilns, the period during which the ware is under heat treatment has been reduced to six days or less, except in isolated cases. The reactions which take place in a continuous kiln are not different from those in any other type of kiln, and it is thus reasonable to assume that what can be done in one type of kiln can be done in another.

The conclusions and designs set forth in the remainder of this chapter are based upon actual observation and practice. The observations upon which they are based covered a period of inspection of many thousand kilns, located in many different sections, and burning nearly every variety of ware, from all sorts of raw material. Kilns after this design, both round and rectangular, have maintained an average burning time of six days or less, on shale and fire clay brick and shale block, on several different plants located at widely separated points. The fuel consumption does not exceed 1,000 lbs. per 1,000 common brick equivalent, and the recovery of first quality ware averages 90% or over. The important points on both round and rectangular kilns are covered, but the relative merits of the two types is largely a matter of personal choice. It may be said, however, that the rectangular type is slightly cheaper to construct per ton of holding capacity, particularly when built in large units, while the round is considerably cheaper in upkeep (repairs).

Drainage.

Perhaps more ware is due to damp bottoms than any other cause. No matter how good the natural drainage, put a network of drain tile under and around each kiln, giving the drains a good fall. On yards where natural drainage for kiln bottoms is impossible, put in a sump and keep it pumped out. No kiln can give good results if the bottom is wet.

Foundations.

Kiln foundations should be carried at least to a point slightly below the deepest flue. If it is necessary to build the kilns on soft ground, observe the same rules in designing the foundation as would be followed in putting a brick building on the same ground. In making calculations for this, add the weight of the ware the kiln will hold to the weight of the structure itself. (See also Kiln, continuous, design and construction of foundations.)

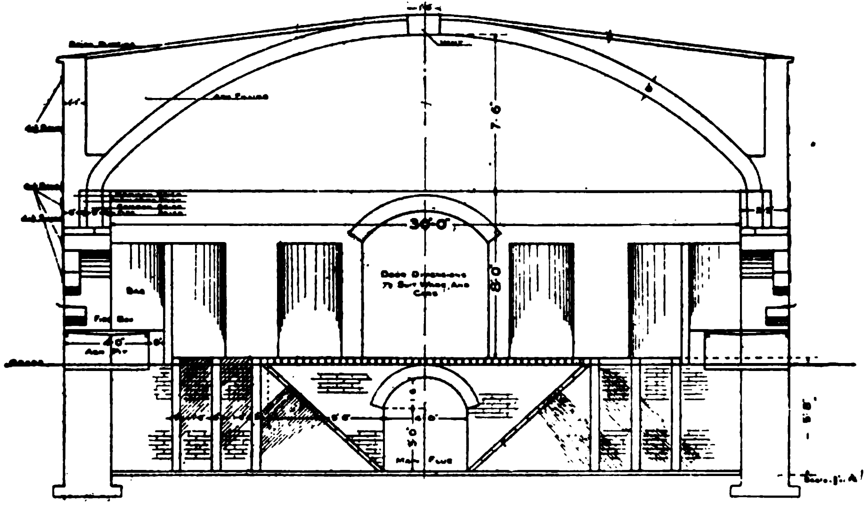


Fig. 1. Thirty Foot Round Kiln.

Bottoms.

In designing a kiln bottom, the chief considerations are (1) an equal distribution of the gases, (2) good draft, especially in the water-smoking period, and (3) ease of cleaning. The first gives good ware over the whole bottom; the second quick burns, and the third saves tearing up the floor and keeps the kiln in commission the maximum amount of time.

The dead or solid bottom produces a higher percentage of defective ware and takes longer to burn. As for keeping the flues clean, this can be easily accomplished in a well-designed riddle or checkered bottom. In a checkered bottom kiln you get good distribution of heat and, with deep flues, good draft and easy cleaning. Fig. No. 1 and 2 show the method of laying out the bottom of a round kiln. By designing a deep, wide auxiliary flue, running at right angles to the main or stack flue, thru the center of the kiln, all of the secondary flues can be given a slope of approximately 45 deg.; this enables the latter to shed any sand, dirt or chips into the larger flues, whence they are easily cleaned out thru the manhole. A much simpler bottom is obtained by omitting the auxiliary flue and sloping all secondary flues to the main flue; but in this case some will not have slope enough to shed and it will be necessary to rake them down at times. So far as burning results are concerned there is very little difference.

Note (in Figs. No. 1 and 2) that the large flues are wide enough for the passage of a wheelbarrow and high enough for a man to work in. Even where sand is used in setting, such a kiln will run for several burns without the draft being affected by the choking. This type can also be cleaned out while the setting is going on, a decided advantage on plants short of kiln room.

In Figs. No. 3 and 4 is shown the method of laying out a rectangular kiln bottom. All that has been said with reference to the round kiln applies to this type.

Theoretically, deep flues are incorrect, but in practice the deep main flue has been found to give a distinct advantage during the water-smoking period; i. e., good draft and no water settle. In kilns of this design, even where the ware was set continually in a distinctly wet condition, there has been found no sign of water settle. The dense, moisture-laden gases of the water-smoking period have more opportunity of getting clear of the bottom courses than with shallow small flues.

Referring to the construction of kiln bottoms, it is very bad practice to partially fill in the kiln excavation with earth, and then build the secondary flue walls or feathers on this filling. If this is done it will necessitate the trouble of at least partially rebuilding the kiln bottom within six months. All filling should be done with hard burned brick or bats. If nothing else is used in the bottom and the masons are prevented from using too much mud, the original bottom will remain level for years. It is good practice to allow the paving course to dip slightly toward the center of the kiln. This will allow the ware to lean away from the fires and in a measure will tend to overcome the "pull" of the outside courses.

Stacks.

Cracked and shaky looking stacks detract from the appearance of any yard. Also, a poorly designed stack may cause an otherwise efficient kiln to give poor results. In round kiln construction a stack is usually built to serve two or four kilns. With rectangular kilns, the single or cheapest stack may be used, but the multiple stack system is the most economical and most popular.

Single stacks should always be built with a separate lining (see Fig. No. 5). This lining need not be more than four inches thick, and is separated from the outer casing by a 3-in. air space. Occasional headers should be shoved out of the inner lining so as just to touch the outer shell; this prevents the closing of the air space. In such a stack, the inner lining moves up and down freely with the expansion and contraction and prevents any cracking of the outer shell. When two or more kilns are attached to the same stack, a separate inner stack should be built for each kiln, for when two kiln flues enter the same stack flue, the draft of one always detrimentally affects the other. If the inner stacks are not built separately, but are, as is frequently done, divided only by a single wall, the temperature difference between the two sides will soon wreck the entire inner stack.

Sometimes the inner stack is carried only a few feet above the point where the flues enter. This is an error, as experiments during the last decade by one of the largest clay products companies have proved decisively that this practice is only completely successful when the inner lining is carried up at least two-thirds of the total height of the stack.

Height of Stack for Kiln.

It is generally conceded that a 30-ft. round kiln or a single-stack rectangular kiln of equal capacity should have a 40-ft. stack, altho this can be slightly modified if the kiln is located on high ground.

The question of stack area is extremely important. Greaves-Walker has found, after years of close observation and experimentation, that the best results on the single-stack type of kiln are obtained by providing one sq. ft. of cross-sectional stack area for each 11 sq. ft. of grate area. Thus, in a kiln with 90 sq. ft. of grate area, a stack should be designed having a cross-sectional area of approximately eight sq. ft. Other engineers reach approximately the same conclusions by different methods, but the one set forth seems to be the simplest yet devised and therefore the most useful.

A trouble found with most multiple-stack kilns is that they generally have too many stacks. This is particularly true of earlier kilns of this type. In such cases a number of stacks will "back draft;" that is, draw the wrong way during various stages of the burn, thus prolonging it. In some cases, half the number of stacks in kilns of this kind have been bricked up, with the result that the burning time has been reduced by one-half.

On account of the more equal distribution of the draft, and the fact that less work is required of them individually, the stacks on a multiple-stack kiln need not be as high as for the single-stack type. However, the ratio of stack area to grate area is greater. In the multiple-stack type the proper ratio is one sq. ft. of cross-sectional stack area to 9.2 sq. ft. of grate area.

It is good practice to provide one or two stacks at each end of the multiple-stack kiln, no matter what the length. These stacks insure better draft at the wickets — spots to which it is usually hard to pull the heat in any kiln. The stacks should be equally spaced, as nearly as possible, on each side of the kiln, and, aside from the end stacks, one side stack should be provided for each three fire boxes.

The proper draft will be maintained if the stacks are carried up to a point six feet above the inside top of the crown.

Dampers.

A great variance of opinion prevails among clayworkers as to the best method of dampering a kiln, or as to whether a damper is necessary. It is obviously impossible to get the required results with all types of clay when no dampers are used. Instances of this would be dark flashed face brick and salt-glazed ware. In some cases, under the direction of expert burners, perfect results can be obtained without the use of dampers. However, since only about one plant in fifty is equipped with experts, a kiln is required which can be handled by the kind of labor that is within the reach of the other forty-nine.

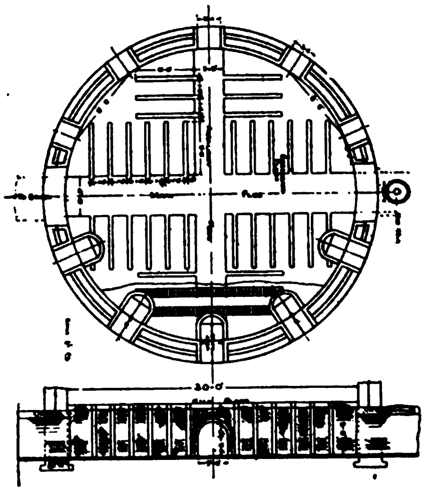


Fig. 2. Thirty Foot Round Kiln Bottom.

Many types of efficient dampers are available. The hinged damper at top of stack is very good, but not at all popular because of constructional difficulties. The sheet damper, dropped into the stack flue or shoved into the stack, is simple and efficient, but when made of sheet or cast iron becomes troublesome thru warping, and when made of fire clay slabs or bricks it is cumbersome to handle.

Another type, efficient and easy to operate, except in cases where much flashing is done, is the wicket damper. It is merely an opening near the base of the stack equal in area to the cross-section of the stack. When the kiln has full draft this opening is closed with brick, mudded over. As it becomes necessary to cut the draft the brick are removed from the wicket one at a time. The rush of air into the stack thru the opening thus made, cuts the draft in the kiln as effectually as tho a sheet had been shoved into the flue. If more draft is required after once cutting, the brick are replaced in the wicket. In the single stack it is necessary to choose one of the above methods and put up with the difficulties encountered.

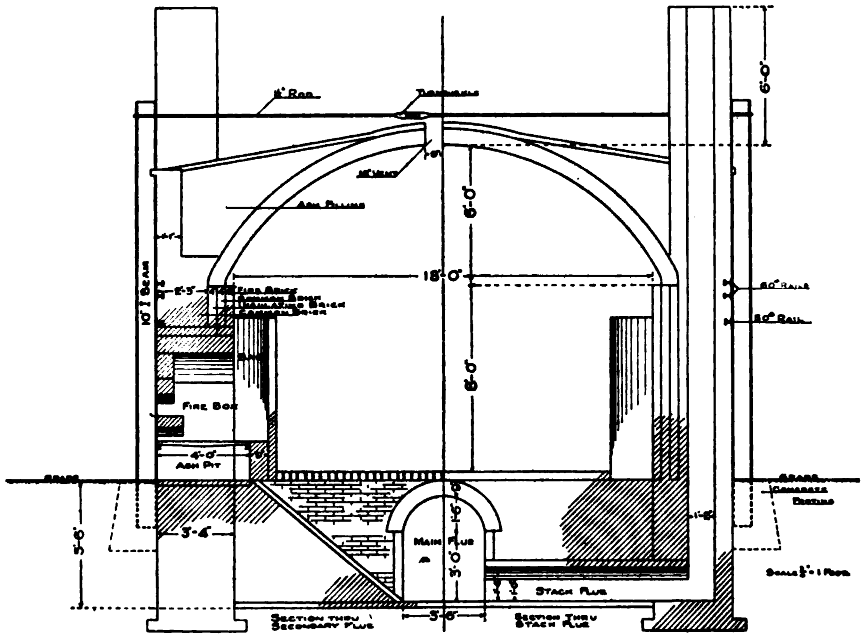


Fig. 3. Rectangular Kiln.

Multiple-stack rectangular kilns are likely to require more dampering than the single-stack round type, unless operated by expert burners; this is caused by allowing the fires to get hotter in one part of the kiln than another, the heat from the balance of the kiln being naturally drawn toward this "hot spot." Some means must be used to correct this condition, and the damper is usually resorted to in an effort to drive the heat to the cooler portions. It is conceded by experts that a damper is not necessary to correct such a condition, but the great majority of burners are not capable of handling the situation without a damper, which therefore becomes a comparative necessity. The kiln design has much to do with the case. Proper stack, flue and fire box proportions tend to make it easier to control and prevent such conditions.

When dampers are necessary in a multiple-stack kiln, the easiest and cheapest one to use is a flat sheet of iron laid on top of the stack. The stacks are, as a rule, low enough to reach from the top of the wall or platting. Any of the methods suggested for a single-stack kiln may be used on the multiple-stack type.

Walls and Crowns.

There is no standard thickness for kiln wall, but there is a maximum limit to which it is necessary to build them. Three points are generally kept in mind by the clayworker when building a kiln: He wants (1) a wall of sufficient thickness to stand the strain; (2) a wall of such thickness as to prevent excessive radiation, and (3) a wall thin enough to conform to good fire box design. Walls can be found all the way from 18 ins. to 6 ft. thick.

The 18-in. wall referred to fulfilled all requirements of strength and got away from concentration of heat in a deep fire box, but it allowed excessive wall radiation. The 6-ft. wall got away from excessive wall radiation, but concentrated the heat in the fire boxes, thereby entailing heat losses in the walls and high repair charges thru the frequent burning out of fire box arches.

These difficulties must be borne in mind in determining the thickness of kiln walls. Considered from all angles, thin, straight walls are best, if they can be insulated, as in this case the fire box is thrown inside the kiln and the fuel does not waste a lot of its energy in heating up and burning out the walls. The setting space lost by projecting the fire boxes into the chamber is a considerable item, but cannot be compared with the saving of time, fuel and repairs during the life of a good kiln. If an uninsulated wall is built, it must be as thick as possible and still be compatible with good fire box design.

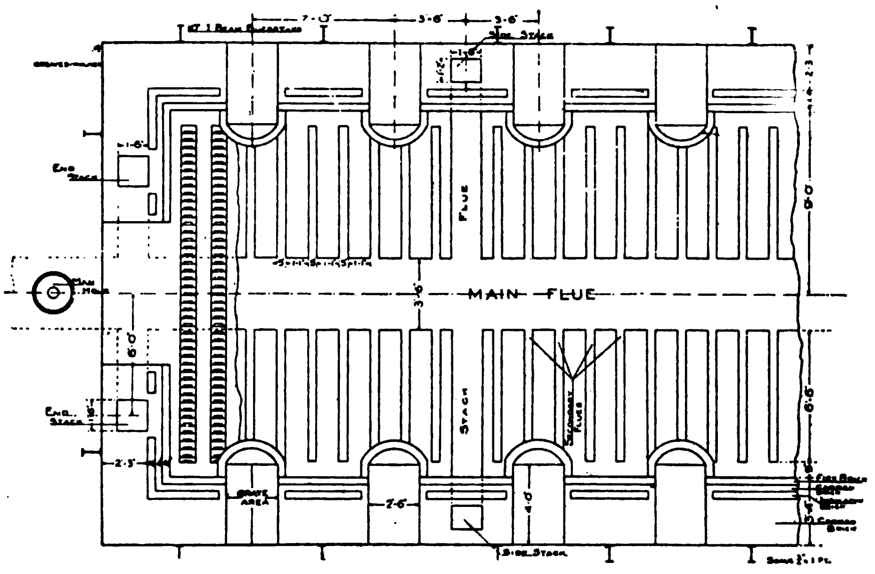


Fig. 4. Rectangular Kiln Bottom.

Generally, the walls of rectangular kilns are built thicker than those of round kilns; this is made necessary by the difference in the methods of ironing the walls. The bands on a round kiln are much more efficient than those on a rectangular kiln.

Efficiency of Down-Draft Kiln.

Before going further into this subject, the efficiency of the down-draft kiln may be considered. The results in the following tables represent heat balances taken on three kilns working under normal conditions, and probably represent average conditions on the average yard, taken the country over. The work was done under the supervision of Prof. A. V. Bleininger, U. S. Bureau of Standards.

1. Sewer pipe kiln—burned to 2,000 deg. F.: Heat lost by flue gases (thru stack), 18.60%; heat lost by ashes, 4.58%; heat lost by radiation and cooling ware, 71.10%; heat actually used in burning ware, 5.70%.

2. Paving brick kiln—burned to 2,030 deg. F.; Heat lost by flue gases, 29.9%; heat lost by ashes, 3.9%; heat lost by radiation and cooling ware, 54.9%; heat actually used in burning brick, 11.3%.

3. Building brick kiln—burned to 2,000 deg. F.; Heat lost by flue gases, 27.33%; heat lost by ashes, 3.51%; heat lost by radiation and cooling ware, 49.61%; heat actually used in burning brick, 19.55%.

Experiments have shown that approximately 25% of the heat stored in a kiln just off fire is recoverable for use in waste heat drying. This, according to the above table, leaves approximately 25% a dead loss. Considering the last and best case cited above, these figures mean roughly that on an average yard, burning coal at $2 per ton, and using 1,200 lbs. (or $1.20 worth) per thousand brick, only 24 cents in actual value is actually being used out of each 1,200 lbs. In other words, 96 cents worth of coal is being lost out of each 1,200 lbs., or $1.60 out of each ton costing $2.00. A rather staggering loss; but the important point is that out of each $2 ton of coal, 50 cents worth is being lost thru the walls and crown.

Taken the country over, a good majority of kilns are probably losing more than 25% of their efficiency thru the walls and crowns, and in many cases they are burning coal costing from $4 to $6 per ton.

Yet to a great extent this loss is preventable.

For a number of years, metallurgical engineers have experimented on furnace walls, using various methods of construction and various materials. The dead air space or hollow wall has been thoroly tried and found wanting. This is not due to the dead air space, since all successful insulating is based upon it. The trouble is that large air spaces are not efficient at very high or very low temperatures, such as prevail in furnaces or ice houses. The air space must be infinitesimal in size in order that circulation may not be set up when there is a temperature difference between two of its walls or sides. Also it is impossible to prevent leaks into large air spaces from the outside or inside, under the conditions existing in a furnace or kiln. Of course, this utterly destroys its usefulness.

New Form of Insulation.

The essential consideration, therefore, has been to find some material which had the properties of hollow air space, that would resist high temperatures, and at the same time prevent the setting up of air currents. Several kinds of diatomaceous earth have been most successfully used, the one known as kieselguhr being perhaps the best known. Large deposits of it exist in California, and it is now being made into brick or blocks of standard fire brick size. It is also used in its raw state in a furnace wall as is cork or sawdust in a fireless cooker or ice house.

One inch of this material has insulating qualities equal to 12 ins. of common brick. Therefore one brick is equal to 12 common brick in thickness in a furnace wall. Numerous university laboratory tests show that a 4-in. lining of insulating brick in a furnace wall which is under constant heat, will prevent 50 to 75% of the radiation. In a kiln, the saving would be even greater, since it is heated up only periodically. Theoretically, it is estimated that a saving of $9.75 per kiln would thus be effected on a 30 ft. round kiln with a holding capacity of 65,000 building brick, where coal costing $2 per ton is used, and 1,200 lbs. of coal are required per 1,000 brick. This is based on the figures given for the loss on a kiln of brick used in conjunction with the 50% saving derived from the use of a 4-in. lining of insulating brick. In actual practice, the saving would undoubtedly be greater than this; but accepting it as a basis on a kiln turned twice a month, the saving per kiln aggregates $234 a year.

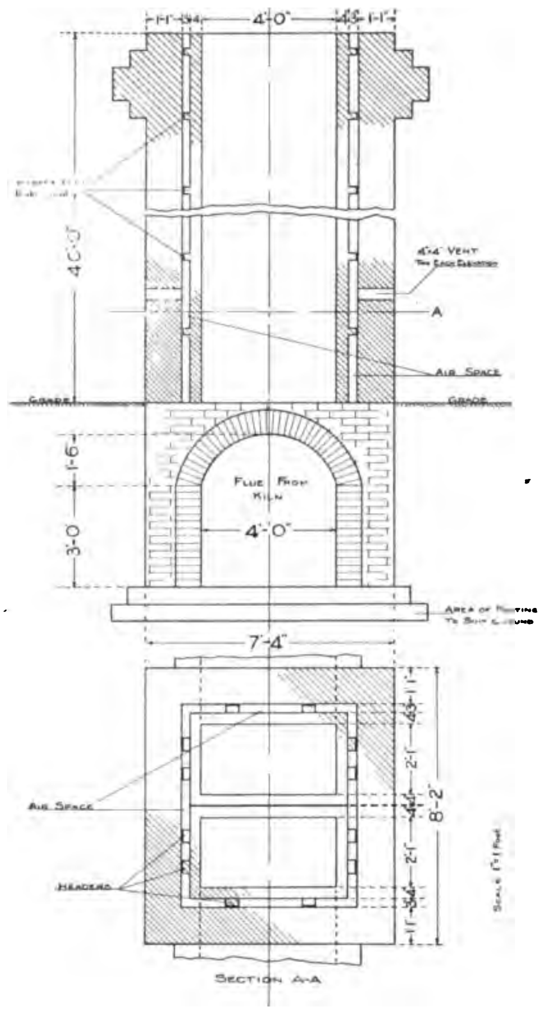


Fig. 5. Two-Stack Kiln.

Cost of Insulation.

In no section of the country should a 4½-in. lining of this material for a 30-ft. kiln exceed $100; in some sections, it may drop to one-half that amount. Since it replaced an equal amount of common brick and the wall will be built considerably thinner, it can be conservatively figured that $30 to $40 worth of common brick will be replaced. To this saving and the saving on heat loss must be added the increased speed in burning.

Fire brick is often wasted in a kiln. Where temperatures not exceeding 2,000 deg. F. are used, 4½ ins. of good fire brick is sufficient. A fire brick lining is seldom touched, except over the eyes, even where very high temperatures are reached. In a round kiln it is not necessary to tie the fire brick lining to the common brick, as in this case the lining may expand and contract without reference to the main wall, and it is much easier to repair.

In such a kiln the shape will prevent it from pulling away if the fire brick are laid well. If the lining is tied in, it should be laid alternate headers and stretchers, or not to exceed two stretchers to each header. Greater spacing of the headers leads to their being broken off by expansion, leaving the lining free. In a rectangular kiln it is always necessary to tie the fire brick to the backing.

In an uninsulated round kiln, the proper depth of the fire boxes must be considered in determining the wall thickness. For best fire box results it should not be over 40 ins. Walls of rectangular kilns when uninsulated should not exceed 48 ins. in thickness. When insulation is used, the round kiln wall may be 27 ins. and the rectangular kiln wall 36 ins. When possible, porous brick should be used in the interior of the wall, as they are better insulators than hard ones. It pays to make up brick for this purpose by mixing a portion of sawdust or coal slack with the shale or clay.

Down-Draft Kiln Construction.

It is scarcely an exaggeration to say that 50% of kilns built are practically wrecked within the first five years thru poor workmanship in construction. Little, if any, attention is paid to the proper tying together of the wall in an endeavor to make it act as a unit, and little attempt is made to allow for any expansion. Poor mortar is often used, and it seems a rule to avoid the use of cement mortar. Ordinary lime mortar, as mixed by brickyard labor, is totally unfit for kiln construction. A 3-to-1 cement mortar, with 10% lime putty added, is probably best. The wall should be thoroly bonded together, and every precaution taken to prevent masons from filling up large cracks and holes with mortar. The use of chips and small pieces of brick should also be avoided.

Various methods, some of them theoretically good, have been devised to allow for the expansion of walls and floors; yet in most cases, these methods, in actual practice, are very poor. Any expansion joint which can become filled with sand, mortar or chips will simply help to wreck the kiln. Allowing for expansion in the vertical joints by means of a mortar joint of proper thickness is unquestionably the best method. This applies to both fire brick and common brick, and necessitates the use of a trowel thruout. In fact, the variation in shrinkage in fire brick requires that the mud be applied with a trowel. This does not necessarily mean that the joint should be thick. If it is made thin and each brick malleted down to a level, a far neater and more serviceable job can be gotten than by dipping. Furthermore, no more time is consumed in laying.

Ironing the kiln walls properly is essential to kiln success and economy. There is no good judgment in spending $2,000 to $5,000 on a kiln, and cut from five to seven years off its life by skimping on the iron work; for no matter how carefully the kiln has been constructed otherwise, if it is not properly ironed it soon becomes wasteful. Cracks in the walls will appear, admitting large volumes of cold air to the kiln, and in a few years it will become so cracked as to be practically worthless.

Steel Shell Kilns.

For round kilns, the steel shell is most efficient. It holds the brickwork absolutely in place, and cracks positively cannot open up. It is also a good non-conductor. The only argument against it is first cost.

Next to the steel shell comes the kiln that is banded so as to catch every course of brick. It, however, is about as expensive as the steel shell. It thus becomes necessary to consider the minimum amount of ironing necessary to keep the kiln in good condition. Using Harrop's method of calculating the size of a crown band necessary on a 30-ft. kiln, one band 6 ins. by ⅛ in. is found sufficient. Some, however, advise the use of two bands at the crown seat, since crown bands, especially light ones, sometimes break, and if two bands are used one may break and still do no damage. It is very good practice, therefore, to provide two 6-in. by ¼-in. bands set three inches apart at the crown seat. Below them, one 6-in. by ¼-in. band is set at the furnace arch, just catching the top of the arch brick or block. Central between this band and the lower crown band is set another of the same size. Under these bands, spaced nine inches apart, vertical slats, 4 ins. by ⅛ in., should be placed, extending around the kiln. These slats should be caught firmly under the crown band and the bottom band. Above the crown bands, two 4-in. by ⅛-in. bands should be placed, but no slats are necessary. In a round kiln, with the furnaces properly proportioned, the distance between the furnaces is comparatively small and the opportunity for expansion in all directions is so large that irons are unnecessary to prevent deformation. The brickwork at these points, however, must be particularly good or bad results will follow.

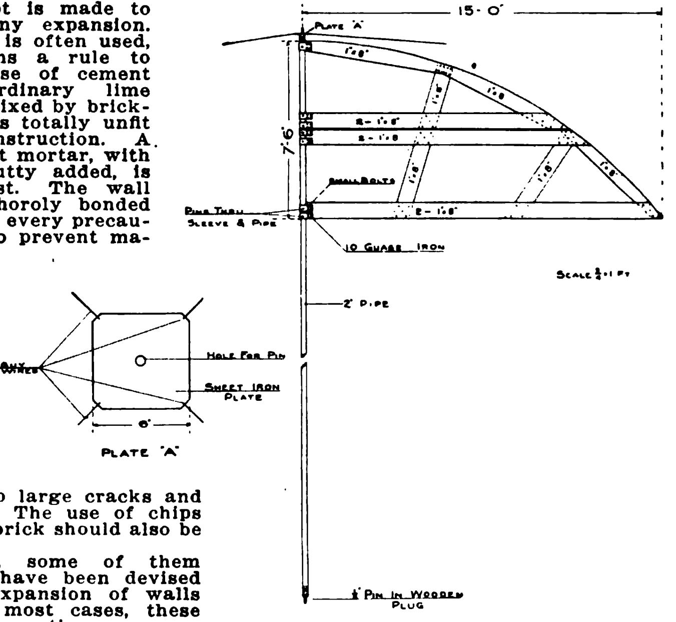


Fig. 6. Thirty Foot Kiln Sweep.

Ironing Rectangular Kilns.

For ironing rectangular kilns, 10-in. standard I-beams should be placed between each fire box; also two at each end. At the crown seat, two 60-lb. rails or one standard 8-in. channel should be set into the wall. At each end one rail or smaller channel should be placed at the same height. Below these, in the same positions as described for bands on a round kiln, 50-lb. rails or 6-in. channels should be used. Rails, when used, should be set with the bottom out.

The I-beam should be tied together with 1¼-in. rods across the crown; it is very important that these rods should always be kept tight enough to "sing" when tapped with a hammer. Many crowns are ruined by allowing these rods to slacken and remain loose. They have a bad habit of constantly stretching and require careful watching. A rectangular kiln is most liable to injury when cooling; during the firing period the rods are stretched and when the kiln cools down they do not return to their former length, thus allowing the crown to settle slightly after each burn. This soon results in a dangerous or wrecked crown.

The Kiln Crown.

Authorities agree that a down-draft kiln should have a life of 15 years; that is, it should not be necessary to rebuild the walls and crown during that period. Yet the majority of kilns require at least two crowns during that time, making it obvious that something is wrong with the design or construction, or both.

Crown Spring Accurately Determined.

The proper spring or circle of a crown for both round and rectangular kilns has been accurately determined by experiment. For a round kiln, the distance from a line drawn thru the points where the crown springs from the wall to the top of the inside of the crown should be one-fourth the diameter of the kiln. For a rectangular kiln, this distance is one-third of the inside width. These figures have been determined as the best for obtaining a crown with longest life, and also as best for burning results. It is known that a kiln with a high crown consumes more fuel per unit of ware, takes longer to burn, and gives poorer bottoms than a kiln with a lower crown. However, if the crown is too low the top ware is likely to be overburned or the capacity of the kiln decreased in an effort to avoid setting too close to it.

Concerning the proper method of starting the crown off the walls, the skewback has undoubtedly dropped out of use to a considerable extent, being replaced by an arc of a circle of very small radius up to the point where the proper circle of the crown is reached. Theoretically, it has been proved by Harrop that the crown started on skewbacks exerts less total thrust on the crown bands than do the other type crowns, but this thrust is exerted along a single line. Thus, in the case of a crown started from an arc, the total thrust may be greater, but it is distributed over an area equal to the entire height of the starting arc, and at any given point is comparatively small. On a round kiln, should the crown bands break in the case of a skewbacked crown, the whole thrust of the crown is exerted along the line of the bottom of the skew with nothing but the friction of a single mortar joint to stop it from shearing off and causing collapse. Where the arc is used, however, all of the backing (which in this case is particularly heavy and should be well tied together), from the point where the crown starts to the top of the arc, must be pushed out before collapse can take place. Moreover, each brick in the arc is really a skewback and we therefore have the total friction offered by a number of mortar joints instead of a single one.

In actual practice, a number of instances have been reported where the arc has been used, in which crown bands broke under fire, and the crown did not suffer at all. On rectangular kilns it is harder to justify the use of the arc, but in this case also it seems more reasonable to distribute the thrust over a large area of backing wall than to concentrate it on one joint.

Support Crown on Main Wall.

Starting the crown is another important point. Instead of supporting the crown on the fire brick inner lining, it should be set back on the main wall. Invariably, crowns crack badly over each fire box. This is partially due to the greater expansion over each eye and partially to the continued burning away of the lining at this point. Also, it is generally noticeable that when it is necessary to repair the fire brick lining over the fire boxes, a portion of the crown often comes down during the tearing out process. If the crown is set back off of the lining and is entirely independent of it, most of this trouble will be overcome.

In building a rectangular kiln crown, the use of forms and lagging makes it easy to obtain the proper circle. In round kiln construction several methods are used to obtain the correct circle. Fig. No. 6 shows a simple one. One of the best features is that if a course of brick slips out of place, it must be put back before the gage will revolve. This prevents the mason from "slipping something over."

Good Workmanship Important.

A crown of theoretically perfect design means little unless the workmanship is first class. Even a poorly designed crown, carefully built, will give long years of service. To build a perfect crown, there should be no variation in the shrinkage of the fire brick, and they should be dipped and malleted into place. In careful metallurgical furnace construction, a minimum variation in size, often as low as 1/16 to 1/18 in., is demanded. With such brick, perfect work can be done with dipped brick. Under average conditions, however, by far the best job can be done by using a trowel and malleting the brick to a level coursing, at the same time using the smallest amount of mortar possible.

In a round crown, each course should be keyed tight with a driven key. In a rectangular kiln the courses should be brought up to a point where the key will go about half way to its seat with the pounding received from a wooden mallet. It should then be forced home with a sledge hammer and wooden block. If the superintendent or engineer properly attends to the keying up, much money and trouble will be saved thru the long-lived crown that will result. This is a job that should never be left to the mason's judgment.

Vent holes may become sources of weakness in a crown. For this reason they should be built of special block.

Rectangular kilns, up to 50 ft. long, require only one expansion joint at each end and none in the middle. Over 50 and up to 100 ft., an additional joint should be left in the middle. Expansion joints in crowns are invariably sources of weakness. The covering for an expansion joint should be "built in" whenever possible.

Crowns can and should be insulated. If a 13-in. wall is carried up from the base of the crown to within 18 ins. of the top, and the space filled in and tamped with fine, burnt-out ashes, a very good insulation will be secured. Over this filling a lagging of brick should be laid and this covered with a coating of lime-cement mortar. Burnt-out ashes, especially the light, fluffy kind, make excellent insulation and are generally procurable on a clay plant. Unburned carbon should always be removed.

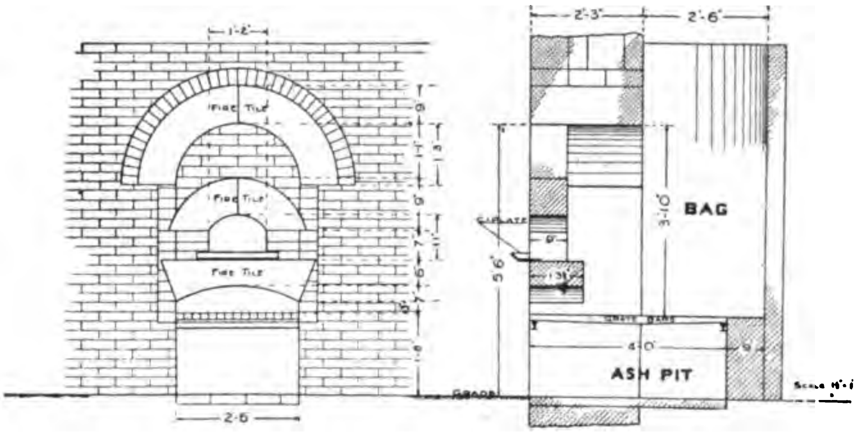


Fig. 7. Fire Box.

Furnaces.

This is not an attempt to convince any one that any special type of furnace is best. There are many good ones, when used under proper conditions. The one described merely represents one of the best types for average conditions, fuel, labor, and material considered. A furnace to be adaptable to the average clay plant must be (1) so designed that it will properly combust ordinary or low-grade fuels; (2) capable of being efficiently handled by the average laborer; (3) easy to control and to produce either reducing or oxidizing conditions; (4) have a low upkeep.

A very important item in kiln design is the ratio between grate area and kiln floor area. If best results are to be obtained, the definite limits to this ratio must be observed.

The upper limit is one sq. ft. of grate area to four sq. ft. of floor area; the lower limit is one sq. ft. of grate area to eight sq. ft. of floor area. For average conditions, perhaps a ratio of one sq. ft. to 7.5 sq. ft. is best. For burning fire brick, the ratio should approach the upper limit—one to four; while for handling a clay with a short vitrification range, the lower limit would be best.

Grate Area Ratio Important.

For best results in salt-glazing the limits should be confined between one to six and one to eight. In going below the one to eight ratio, dull ware will likely result, while to go above one to six generally means blistered, pimply ware, or at least a considerable percentage of it.

The higher the grate area—floor area ratio—the greater the care required in handling the kiln, especially near the finish of the burn, but increasing the grate area will invariably give greater burning speed.

Fig. No. 7 gives an idea of the furnace suggested. Note that the grate bars are easily accessible, that the furnace is easy to clean, and likely, therefore, to be popular with firemen. It requires no doors, yet can be absolutely controlled, as a couple of shovels of slack will effectually close the feed hole, or it can be left partly or entirely open. Doors are an advantage on any furnace, however, and perfect control and efficiency cannot be obtained without them. This furnace is so simple as to be very easy to keep in repair.

Note especially the distance from grate bars to top of arch, an important item in any kiln furnace. Ample room is necessary over fires if constant repairs to the arch are to be avoided. A low fire box confines the heat and heats up the kiln walls instead of the ware; a high one allows it to get into the kiln where it belongs.

If furnace arches are built of fire clay shapes or blocks, hundreds of dollars yearly will be saved in eliminating the trouble of replacing arches built of brick. Such shapes cost but little more than the equivalent in brick, and their use will enable furnaces to stand for years without attention.

Concerning bag walls, there are not many types to select from; it is a question merely of round or square, high or low. It may be necessary to build a high bag to protect the ware from flashing; to throw the heat more to the center of the kiln; to prevent the ware from being drawn into the fire boxes or to prevent melting. In reference to shape, the semi-circular bag probably gives longest life. In brick kilns, where the setting is run up tight against the bags, the semi-circular type offers greater resistance to crushing and the pull of the fires than the rectangular type; it is also most economical of floor space. (See also several items under Kiln, intermittent, and Kiln, down-draft.)

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.

387—KILN, DOWN-DRAFT, METHODS OF SETTING.—The various methods of setting brick in a down-draft kiln may be divided as follows: Common brick setting; unflashed face brick setting; flashed face brick setting, and enameled brick setting.

Common Brick Setting.

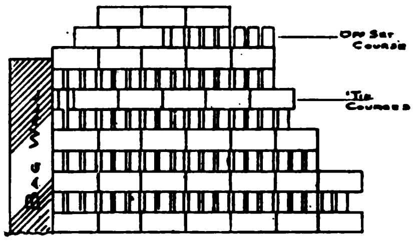


Fig. 1. Front Elevation. Single Header and Stretcher.

The market price of common brick necessitates their being produced as cheaply as possible, and, since color is not a primary requisite, it matters little whether the face is flashed or unflashed. The alternate single header and single stretcher fills all requirements (see Fig. No. 1 and 2). It is quick and can be done by setters with but little skill, and, above all, it is a very stable method. The question as to whether the brick should be set "two on one," "three on one," or "five on two" is simply one of draft and must be determined for each individual case. This is also true in regard to the number of offsets or tie-courses and to the tying-in of the heads.

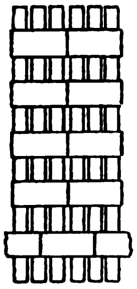


Fig. 2. Section Thru Bench.

The simplest and quickest method of setting common brick is known as the "tight-bolt" method, which is widely used in Canada and England, in both up- and down-draft kilns. As will be seen in Fig. No. 3 and 4, the brick are set in absolutely tight benches, all headers, running from bag-wall to bag-wall. These benches are set approximately one inch apart to allow for draft space and are kept from "rolling" by passing thru an occasional brick in every fourth or fifth course, so that it touches the bench behind. The proper spacing of the draft space is made by a "follow-board," which is pulled up as the bench rises. This is merely a 1-in. plank, with two leather handles, and supported by headers that are occasionally pushed thru as necessary. In rectangular kilns, one follow-board is enough; in round kilns, several are required to accommodate benches of different length.

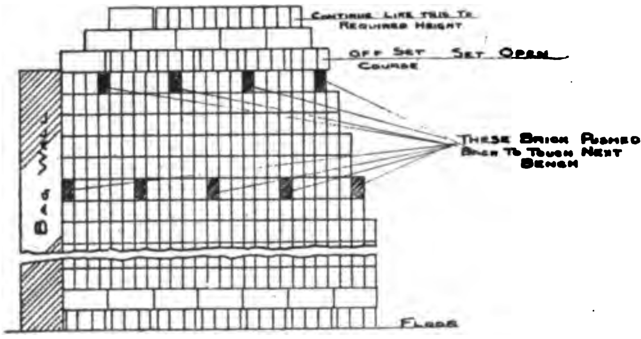

Continue Like This To Required Height
Off Set Course
Set Open
These Brick Pushed Back To Touch Next Bench
Bag Wall
Floor

Fig. 3. Front Elevation of Tight Bolt Setting.

This method, altho at first giving the impression of cutting off all draft and of being too tight, is widely successful, and is obviously very fast. It leaves no chance for "kiln marking" and the brick come out of the kiln with both faces of an even color.

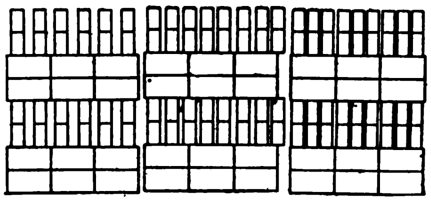


Fig. 5. Showing Double Two on One, Double Three on One and Double Five on Two.

Unflashed Brick Setting.

To prevent flashing, it is necessary to protect both faces and heads. This is done by "facing" the brick and "butting" the heads. The well-known forms of "double two on one," "double three on one," and "double five on two" are used (see Fig. No. 5). With care in burning, this type of setting is satisfactory. It requires great skill, however, since all brick must be perfectly faced or many "seconds" will result. Also, after the first course is laid down, all brick must be set in perpendicular lines, in order that the fire gases may flow unchecked to the bottom.

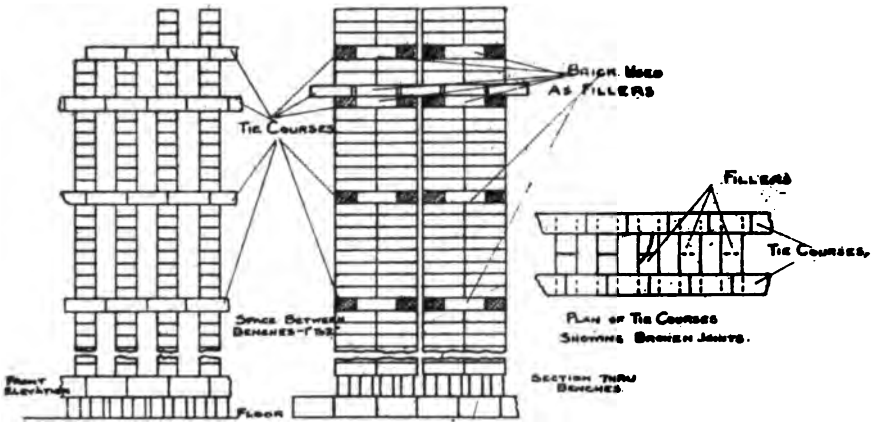


Fig. 7. Method of Setting Whole Kilns on Flat.

Where burning can be done under continuous oxidizing conditions, as in cases where natural gas, producer gas or oil are used, the "tight-bolt" method can be used with success (see description in second paragraph above). With this method only the heads are exposed to the gases under any circumstances, and if these are not flashed, there is the additional advantage of having two faces to select from, with no chance of "kiln marks."

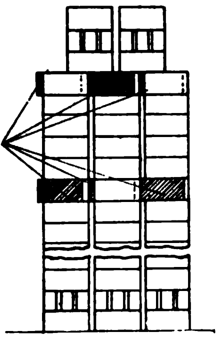


Fig. 4. Section Thru Bench. Tight Bolt Setting.

Protecting the heads exposed above the flash walls is one difficulty met with in setting unflashed face brick. One of several methods used is shown in Fig. No. 6.

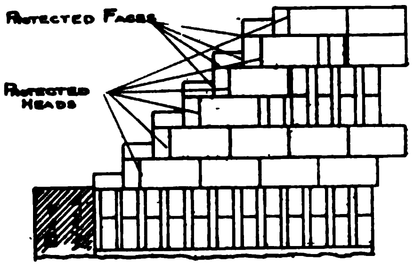


Fig. 6. Method of Protecting Heads from Flash.

Flashed Face Brick Setting.

Setting brick so as to get flashed faces presents many difficulties. Primarily, if entire kilns of flashed faces are required, the difficulty is often experienced of dealing with raw materials which crack badly when set flat to any height. "Rolling" or "tumbling" often results with this method. The setting space is reduced and there is a greater tendency for brick to stick at vitrified temperatures, unless sand is used.

Fortunately, the market for flashed brick has been educated to demand a wide variety of flash marks. This allows the manufacturer to set part of his kiln on edge and part on the flat. In fact, the more varied the setting the greater the variety of marking and color.

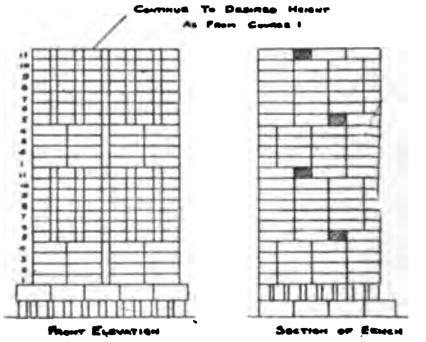


Fig. 8. Method of Setting Whole Kilns on Flat.

In Fig. No. 7, 8 and 9 are shown two methods of setting entire kilns of brick on their beds or flat sides. The question of how many brick can be set on each other before the coursing is broken by a runner or tying-course, and also as to what height the setting can be carried, is one that must be determined for each material. No set rules can be made for this.

In Fig. No. 10 is shown a method which is an adaptation of the "tight-bolt" method. It has proved successful and is very stable, but gives only one flashed face. This, of course, suffices for a rough textured brick, but makes it undesirable for a smooth face. It will be noted that the flashed heads are taken care of in the header courses. In the manufacture of rough textured brick, the general rule is to set combination kilns, part on edge and part flat. The kiln is divided so as to provide the proper proportion of each, or only so many are set on the flat as the material will allow.

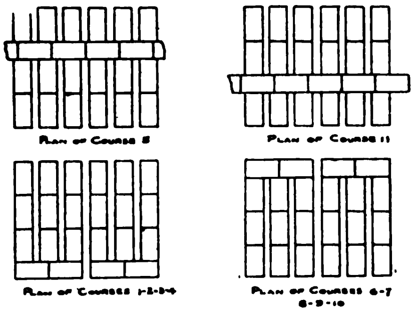


Fig. 9. Plan Views of Settings Shown in Fig. 8.

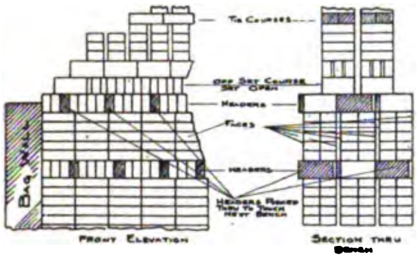


Fig. 10. Tight Bolt Flat Setting. Set Number of Header Courses to Suit Quantity Required.

Fig. No. 11 shows a kiln set in combination. (See also several items under Kiln, intermittent, and Kiln, down-draft.)

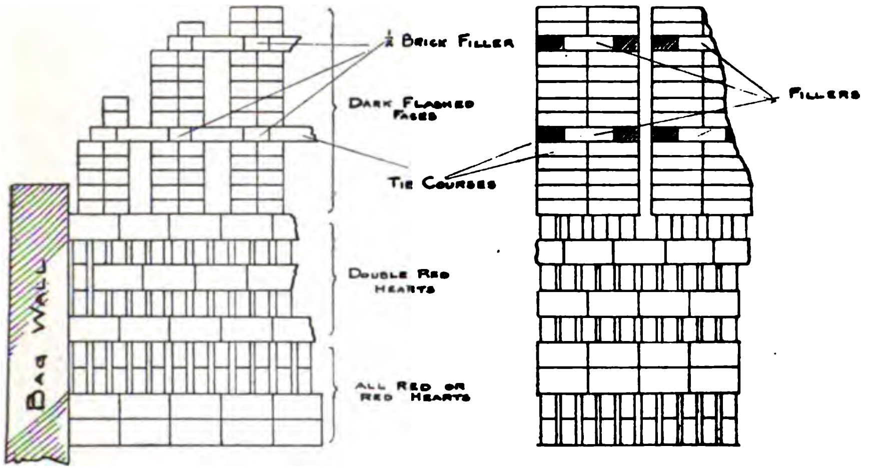


Fig. 11. Combination Flat and Edge Setting.

388—KILN EXPERTS.—These are men whose training and experience qualifies them especially as experts in kiln construction and operation. It has well been said that the operation of the kilns of a plant can make or break the success thereof. While the method of kiln operation cannot correct the mistakes made in previous work on any ware, it can absolutely unmake all of the quality that has been gained thru care in every process. Large kiln losses will cause the failure of any plant. Kiln experts, trained from experience, can show a manufacturer where his trouble lies, can decrease fuel consumption, reduce kiln losses, increase quality, plan new kiln installations and altogether save far more than the charge for their services. (See also Engineer, clay plant.)

EXPERTS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

389—KILN FIRE BOX.—Every type of kiln has a fire box suited to the construction of the kiln. The up-draft kiln really has no fire box except that the green brick are set to form what is called an "arch." The fuel is fed into the ends of these arches, and the corresponding holes thru the wall of the kiln. In burning with oil or natural or producer gas, the burner really constitutes the fire box, altho the brickwork surrounding the burner, where complete combustion takes place, might be termed the fire box. Some continuous kilns are fired from the top and use no fire box, as the fuel is burned in contact with the ware. The term "kiln fire box" is therefore understood to refer to all other kilns where coal is used as fuel.

There are quite a few different types of fire boxes in use. One of the oldest and one that is now used in some sections and in certain classes of the industry almost exclusively, is that with flat grate bars, patterned to a great extent after the old type hand fired boiler fire box.

Others use an inclined grate successfully. At some plants the incline is made of portable bars of iron or steel of various sizes, and at other plants the incline is made of brick built in as a permanent part of the kiln. In a few cases the fire box has no grate whatever. Economy and efficiency are very necessary in the operation of a clay products plant, and the keynote of the entire plant is the kiln. Therefore, the construction and proper proportions of kiln fire boxes are important items. It is necessary to get the proper amount of air for the fuel to be burned and it is also important to finish the burning as fast as can be done without injuring the quality of the ware. In order to control these variables as much as possible, and to burn as economically and as efficiently as possible, many improved fire boxes are on the market. (See also Stokers, hand operated and Kiln, down-draft, design and construction.)

MANUFACTURER (see catalog section):
Canton Grate Co.
Toronto Foundry & Machine Co.

390—KILN FLOOR BRICK AND SHAPES.—Floor brick are used only in down-draft kilns. They vary in size and shape a great deal. Their purpose is to make a level floor on which to set the ware to be burned, with holes or perforations thru that floor, by means of which holes the flame and draft after assisting in the burning the ware in the kiln, pass into the small flues beneath the kiln floor, thence into the main flue and later to the stack. Many plants also use special shaped blocks for the skew of the crown, for the arch over the fire box, and around the vent holes in the crown.

Almost all special shapes are made of fire clay.

KILN, FOUNDATIONS FOR, see Kiln, continuous, design and construction of foundations; and Foundation.

391—KILN, FRIT.—An average size frit kiln, used in the preparation of frit for glazing purposes (see Glazing materials, how to prepare), is about 15½ ft. long, 4 ft. wide, and 4 ft. high; the part containing the frit ingredients is 11 ft. long. The capacity is about 40 tons every two weeks. After having been fired for 3¾ to 4 hours, 600 lbs. of fluid frit flow into a shallow iron tank containing three inches of water. The contact with water soon causes the frit to solidify. The shattered glass fragments are piled high in a bin convenient to the glaze pans or glaze mills. After being used two weeks, the frit kiln is rebuilt and repaired. The process is an English one. (See also Frit and Frit Brick.)

392—KILN INSULATION.—This is effected principally by placing insulating brick or an insulating compound on the crown of a kiln. The same benefit can be obtained by using insulating brick in building the walls of a kiln, but as ordinarily constructed most of the radiation and loss occurs thru the crown of a kiln. Cinders have also been used for this purpose. A kiln for burning the lower grades of ware will have walls of 18 or as much as 30 inches, and have a crown that is very seldom more than 12 inches thick. On kilns for burning the higher grades of ware, we often find walls from 30 to 36 and even 40 inches and crowns of not more than 15 or 18 inches including the platting or top course that is used to keep the rain from soaking into the main crown. High temperature cements are also very satisfactory for laying up the inside walls and crown of a kiln because on account of the fact that they fill up the joints between courses they act as an insulator. (See also Cements, waterproofing; Cement, high temperatures; Cement, insulating; Brick, insulating; Kiln, down-draft, design and construction and Kiln, continuous, design and construction of main walls.)

Placing Insulation in Walls of Tunnel Kiln. Other Kilns Insulated the Same Way.

MANUFACTURERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
Celite Products Co.

MANUFACTURERS' ANNOUNCEMENTS:
Celite Products Co., Monadnock Bldg., Chicago, and nine branch

offices. Sil-O-Cel is the trade name of the material frequently referred to as Kieselguhr or diatomaceous earth. It is practically pure silica, and altho extremely light in weight, possesses sufficient mechanical strength for all insulating purposes. It is furnished in both brick and powder form and may be applied to all types of kilns without change in design. According to U. S. Bureau of Standards, Sil-O-Cel insulation possesses a melting point of 2,930 deg. F. and it withstands without shrinkage a direct heat of 1,750 deg. Tests of insulated and uninsulated kilns prove that from 60% to 70% of the heat lost by radiation can be saved by insulation, resulting not only in lower fuel requirements, but also in increased capacity and in a larger percentage of perfectly burned ware.

393—KILN, INTERMITTENT, MUFFLE DOWN-DRAFT.—Muffle kilns are used in the burning of certain classes of clay goods that cannot be burned in contact with the fire gases. Various lines of pottery, terra cotta, glazed brick, wall and floor tile and other wares that are apt to suffer from flashing, reduction or sulphur discolorations require to be burned in muffle kilns.

The typical muffle kiln, instead of being made up of many small vessels or chambers that are drawn and set each time with the ware, consists of an enclosing chamber permanently built on the inside of the kiln proper. The ware to be burned is set inside of this chamber, after which the chamber is as nearly hermetically sealed as can be done with fire clay mortar. Between the ware and the hot gases is an impervious wall thru which the heat must penetrate before it can affect the ware inside. The heating is done largely by radiation and conduction from the inside of the enclosing wall by the energy that has been conducted thru the brick and clay of this wall. The principal means of transferring heat in ordinary kilns, namely, convection, is therefore eliminated. Consequently, waste of heat in a muffle kiln is enormous, and the kiln can only be employed where the value of the ware warrants such processes of manufacture.

The essential parts of a down-draft muffle kiln are (1) an outer shell similar in all respects to the down-draft kiln, and (2) an inner sealed chamber with space left between the two for circulation of the kiln atmosphere. An improved construction provides a center opening down which the hot gases pass into a well beneath the floor. From this well the gases are distributed thru radial flues to as many exhaust stacks. The object is to keep the gases in contact the longest possible time with the largest possible amount of muffle surface for the space within. The width of the muffle chamber cannot economically be large, as it is difficult to maintain a uniform temperature in a large space where little or no movement of air is possible.

BUILDER (see catalog section):
International Clay Machinery Co.

394—KILN, INTERMITTENT, RECTANGULAR DOWN-DRAFT.—The handling of the output of large brick plants requires that space be economized in every possible manner. The distance which the brick are transferred from dryer to kiln and from kiln to car must be reduced to the minimum. This is accomplished in a large measure by eliminating the round down-draft kiln, which as a rule holds 30,000 to 60,000 brick, and using a rectangular down-draft kiln which holds 150,000 to 200,000 brick. To burn this number in round kilns would require several times the amount of space occupied by the rectangular kiln, and would also entail a much larger expenditure in construction. Thus, the rectangular kiln is a vital factor in economizing space, and, tho not ordinarily as susceptible a contrivance to delicate regulation in burning, is widely used and is eminently successful.

Rectangular kilns are built from 15 to 20 ft. wide and as long as 100 ft. In this style of construction, it is clear that the conditions which must be met in controlling the draft will differ somewhat from those met in the round kiln; but the general principles of draft movement discussed under the latter head (see Kiln, intermittent, round down-draft) will apply equally well to the rectangular kiln. In particulars of construction, namely, kinds of fire place, use of false floor, height of kiln and relation of kiln floor and fire holes, the same rules will likewise hold good for the rectangular kiln.

Comparing Side Stack and End Stack Drafts.

The stack which controls the rectangular down-draft kiln is located at one end or at the side. Experience indicates that it is not possible to obtain good draft regulation over all parts of the kiln by the use of the end stack unless the principles of flue arrangement described under round down-draft kilns are put into effect (see Kiln, intermittent, round down-draft). Nor will a single open flue in the center suffice; this flue must be covered and lateral flues opening into the center flue constructed. The openings from kiln chamber into both central and lateral flues should be proportioned in relative size according to their distances from the stack, and in total area according to the cross section of the stack. Generally, these openings should in any portion of the kiln decrease in size from the sides of the kiln to its center; and be gradually made smaller towards the stack end of the kiln. Their total area should be less than the area of the stack, in order that an equal force of draft may be kept up in each one of the flues.

A common way of operating the rectangular down-draft kiln with an end stack is to divide the flue system into two parts. The main flue is divided by either a horizontal or vertical partition extending to the base of the stack; each part of the flue thus controls a definite portion of the kiln. Dampers in each of these divided flues may be used to change or cut off entirely the draft from one section of the kiln, in which event the whole strength of the stack draws on one part of the kiln only. This arrangement amounts practically to the use of two stacks, each controlling a definite proportion of the kiln space, and is not ordinarily as successful as the graduated system.

The side stack draft usually affords a better control of the kiln. The flue system is here generally divided into three sections, separate flues leading to the stack from each section. By damper control of each flue the flow of gases from any fraction of the kiln can be regulated. This flue arrangement, when combined with proper floor construction, can be made to give excellent results.

Two stacks are also used with the rectangular kiln. They are usually situated at the sides and each controls a share of the kiln. By a central dividing partition in the main flue, good work may be done in the two-stack kiln.

Multiple-Stack Kilns.

Multiple-stack kilns are extensively used. The use of many stacks necessitates the division of the flue system into as many parts as there are separate stacks. Each stack thus controls a small system of its own which is separated from the others by solid partition walls and which may be operated more or less independently of all the others. In the construction of multiple stack kilns, however, it is imperative that there be combined a proper relation between the size of stack and flues, and the correct distribution of the inlets into the flues from the kiln chamber; otherwise even burns are as difficult to realize as in any other class of kiln. But if these requirements are fulfilled, excellent results can be obtained.

Other Considerations.

Some authorities contend the use of many stacks is seldom necessary. The cost of construction and maintenance are usually high. Great care must be exercised in burning where there are many stacks to supervise. And while it is conceded that as perfect work can be accomplished in multiple stack kilns as in other types, these authorities do not approve of dividing among many stacks the work that can be done equally well by a few stacks or perhaps a single stack.

As in the case of a round kiln, some advocate a center stack construction which appears to offer certain advantages. The number of stacks needed would depend upon the kiln length; thus, one stack in a short kiln, and two, three or more stacks in longer kilns. Each stack could control a space about equal to an average round kiln; the radial flues and inlets being proportioned and arranged as in a round down-draft kiln (see Kiln, intermittent, round down-draft). This arrangement in a rectangular kiln would present the same advantages of rapid and uniform heating and general economy as does the center stack in the round kiln, the sacrifice in kiln space being more than offset by other savings. (See also Damper, kiln and boiler, and several items under Kiln, down-draft, and Kiln, intermittent.)

BUILDERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

395—KILN, INTERMITTENT, ROUND DOWN-DRAFT.—The type of down-draft kiln that is used more than any other in all branches of the clay industry is the round single-stack kiln. Numerous modifications of this type have been made, to suit the conditions and clay of different places, but the principles of operation remain the same. The number of stacks used varies widely. The arrangement of flues leading to the stacks and the openings from the kiln chamber into the flues also differ with the various designs.

Any one of the classes of fire boxes now in common use are applicable to the down-draft kiln, but the selection must be based on an accurate knowledge of the clay used and the kind of ware into which it is to be wrought. If it is essential that the kiln atmosphere be uniformly oxidizing, or if the ware is such that sulphurous emanations may be harmful, the inclined grate or dead bottom fire would not be suitable, altho they would be applicable for burning paving brick or other wares that are not injured, and may even be benefited, by an occasional period of reduction.

The burning of all wares thru which the fire gases may be permitted to circulate is accomplished by the transfer of heat from the fire to the ware by these moving currents; this method of heating is called convection. Convection therefore supplies the important means by which the heat reaches the ware in all types of kilns except muffle kilns. The production of an equal draft thru all portions of a kiln of ware thus becomes the primary consideration, if uniform burning thruout the kiln is to be obtained. This is explained by the fact that the fire gases in flowing thru the kiln are influenced by the same factors that effect the movement of any liquid. If unobstructed, they follow the most direct and open path to the exit flue. Consequently, the kiln design should be such that the obstructions will insure a thoro and uniform distribution of draft.

Early Types.

The early round down-draft kiln had but one center opening which led to an outside stack. The gases naturally tended to take the shortest route to this opening from the top of the bag walls over which they entered the kiln. The result was that parts of the kiln between the bags and the draft opening were left unequally heated, so that if the temperature were increased to heat these parts properly, the portions in direct line of the draft were overburned. After a long period of experimentation it was learned that an equal distribution of the draft thru all portions of the kiln can be obtained only by taking the gases out thru openings distributed over the kiln bottom, instead of thru a single well towards which they all naturally concentrate.

Trend of Improvement.

This resulted in the evolution of down-draft kiln construction to the diverse types now in existence, the trend of improvement being largely due to modifications and improvements in the flue systems, and in the arrangement of leading the gases from the kiln into these flues.

An early step in this evolution replaced the center well-hole with an open flue across the middle of the kiln bottom; the flue led to an outside stack. The gases, due to this arrangement, were drawn by the shortest route to this exit, and thus produced a highly heated area in the part of the kiln closest to the stack. Later, this arrangement was modified to afford a flue circling the interior of the kiln and connecting with a diametric flue such as was first used alone. This principle of kiln construction is still in extensive use in some localities. To prevent extreme concentration of draft, the flues in this kiln are closed for some distance in that part of the kiln nearest the stack; this provision does retard the pronounced flow of gases, but as the tendency of the latter to leave the kiln as near the stack as possible is always present, the equality of the draft is disturbed proportionally.

A modification of the foregoing type is obtained by connecting a diametric open flue with the stack by means of a covered flue. In other cases, a series of concentric flues intersect the main stack flue; but the tendency of the draft, in both cases, is usually strongest in the central parts of the kiln.

Further Modifications.

It is obvious that any arrangement which contemplates the final removal of the gases from the kiln, other than from the center of the kiln bottom, must naturally tend to heat the kiln in spots and not symmetrically with reference to the center. As has been discussed, where there is but one outlet, and that a center well-hole, the gases draw directly towards that point; but the fact remains that the draft is symmetrically distributed from circumference to center, and, altho the outer portions of the kiln receive the least draft, it is alike in all similar parts of the kiln. Therefore, any means which will operate to equalize the draft from circumference to center, must be so designed that portions of the gas will be removed from the ware chamber at points distributed over this intermediate area. In general, it is held they should decrease in diameter as they approach the center, the draft directly into the main outlet being practically cut off.

There are many methods used to attain this end. The commonest is to construct radial flues outward from the center. The number of these is usually determined by the number of fire holes, the flues bisecting the area between the bag walls. Occasional openings are made in the flues, the larger the opening the farther it is from the center, so that the outside may draw as strongly as the central portions. The shape of these openings is variable and immaterial, and their number is not fixed. The total area of openings leading into one flue should, however, be less than the cross section of that flue. The sizes of the openings into the radial flues can be determined by experiments, the essential being to establish an equal air velocity thru each and every one. By heating the air column in the stack and producing a draft in the kiln, the velocity of the air movement can be measured by an anemometer and the openings so proportioned that the draft will be the same in each, whatever its location.

The above outlined arrangement may be used to obtain very good results, but is cited only as an example of many equally successful designs.

Effect of Structural Details.

The kiln may be so constructed as to insure a uniform draft, but such construction does not necessarily guarantee a perfect draft when the kiln is full of ware and on fire. The setting of the ware has much to do with the draft; by poor setting a good design may be made to give poor results. It is likewise admitted that a poor construction may be made to give fairly good results by the style of setting; but it is easier to adapt the setting to a kiln which is built on correct principles at first than to remedy any improper construction by the same means. If a kiln is afflicted with "cold spots"—that is, parts where the ware is underburned, and perhaps in other portions overburned ware—it is a sign of inequality of draft, especially if the areas are away from the bag walls, where local heating may occur by proximity to the fires. Such defects may be remedied by a closer setting in the lines of greatest heat and more open setting in the cold portions.

Even with a uniform draft it is commonly found that the bottom ware is less hard burned than the top portions. This results from the fact that the heated gases first come in contact with the top ware and must pass thru it before reaching the ware lower in the kiln. As a consequence it may be stated that the gases, as a rule, are always cooler when they reach the bottom than when they entered the kiln. The more rapidly the gases move towards the outlets, that is, the better the drafts, the farther will their initial heat be carried into the ware, whether it be greater or less than the temperature of the ware itself.

Movement of Gases.

The movement of gases in a kiln may be conceived as that of a wave progressing downwards thru the ware with equal velocity in all parts of the kiln. It will progress thus uniformly until it nears the kiln bottom. Here it is forced to divide into numerous small currents, each diverging more or less from the straight downward path in order to pass out thru the openings which convey them into the radial contributory flues. Obviously, the number of these flues must be limited, and between the openings into them, there must be areas of solid floor space thru which no draft is possible. This splitting, as it were, of the main draft into many small currents may be construed to check or retard the whole movement of the draft; this check being least in direct line with the draft openings, and greatest just above the solid portions of the floor. Thru the ware situated in these intermediate positions the draft is not vigorous, and, as a consequence, there is a percentage of underburned ware in kilns of this construction. In some instances a proportion of underburned ware is not objectionable from a commercial standpoint; but where the difficulty must be overcome, what is known as a false floor may be provided to reduce the loss by underburning to a minimum.

This floor is sometimes made of the green brick to be burned. In this case the lower courses are set as openly as possible, yet close enough to afford a firm support for the ware above, and arranged to furnish room for a free and unretarded circulation of the gases in reaching the outlets. In this manner the check which the movement of the gases suffer is less pronounced and the number of underburned brick is considerably less than where such provision is not made.

The majority of recent down-draft round kilns have what is called a permanent false floor, especially kilns used in burning vitrified wares. This floor eliminates the necessity of making a re-set of green brick with each new burning; it forms, instead, an essential part of the kiln construction. It is built of fire brick and so supported with open brickwork as to leave ample space below it in which the gases may circulate unimpeded in finding their way to the flues. The floor itself is generally made of some special design of brick, their shape being such as to permit the freest possible escape of the gases thru them and yet possess the requisite strength.

Value of False Floor.

This false, or, as it is commonly called, checker floor construction, gives an unretarded passage to the draft completely thru the ware with equal facility at all points into the open space below the floor, where it is at liberty to seek the most convenient exit to the stack. The ware is thus brought to a substantially uniform temperature to the bottom of the kiln. However, all the false work of the floor is brought to the highest temperature of burning, and is therefore a source of loss of heat which does not exist where the false floor is built of green ware. The continuous flow of gases, which is facilitated by the use of the checker floor, is an important factor in burning those classes of wares in which flashing is detrimental. The false floor is thus a desirable accessory in kilns of the paving brick and sewer pipe industries and also in the manufacture of front brick, altho in the latter a good flashed product is often sought after. In this event, it is no less difficult to secure flash effects in a kiln of this design than in kilns where the false floor is absent. All glazed ware can likewise be more successfully burned in kilns provided with a false floor.

Cause of Variations in Draft.

The force of draft thru a chimney depends on the difference in weight between the column of hot gases within the chimney and that of a similar column of atmosphere outside. This difference in weight, or pressure, is due mostly to the difference in temperature, being influenced also by the humidity of the air in question. From this it will be seen that chimney drafts may vary not only because of the difference in temperature but also according to the composition of the gases themselves and the condition of the weather.

This difference in weight may be calculated by a well-known mathematical formula, or may be measured directly by a draft gage or draft meter. (See also Draft gage and meter.)

Importance of Stack Design.

The fundamental consideration is that the original construction of the kiln with flues and stack be such as to insure the correct proportion of each of these vital factors to the other. The stack is the real draft producer. It is built of brick or sheet iron; the former is more expensive but usually gives better satisfaction, as the thin and readily conducting shell of sheet iron rapidly dissipates heat by radiation. A very substantial and serviceable stack, altho expensive, is made of sheet iron lined with fire brick to prevent radiation.

The cross section of the stack should decrease towards the top. Experience has shown that the tapering construction will largely prevent counter currents from flowing in at the top which are a source of more or less difficulty in straight stacks. The size and height of the stack should always be such that the full capacity will seldom be needed. That is, the stack should possess a reserve force that, under average working conditions, may be held in check by a damper, but which is always available when emergency demands.

The natural tendency of air and fire gases as their temperature is raised and they expand is to rise. In all up-draft kilns this tendency is satisfied by the ready escape to the stack, the movement being always in an upward direction. In down-draft kilns the reverse is true, and the gases must first move downwards thru a mass of ware before they can reach the stack. They must move contrary to their natural tendency and apparently in opposition to gravity.

Due to this condition, when gases from the fires first begin to pour into a down-draft kiln they tend to accumulate in the crown, since they are lighter than the cold air already filling the kiln. But they cannot escape upwards and their expansion necessarily gains relief downwards by forcing some of the heavier cold air out at the bottom. As the hot gases from the fires continue to pour into the kiln the warm air progresses downward, continually forcing out thru the stack the cooler air in the bottom of the kiln. In this manner a draft is gradually established. The shorter the distance which the air must travel downward the sooner a draft is set up. Obviously, the gases must travel to the height of the kiln chamber; but the shorter the distance beyond this that they are required to go the better. For this reason it is advisable to avoid the construction of deep flues. The shallower the flues are (as long as they furnish the required cross section area), the more favorable will they be to freedom of draft; that is, the sooner the gases can be conveyed to the chimney after they have passed thru the ware the more efficient does the draft system become. This rule also involves the reduction of the distance thru which the gases are to be carried laterally the greatest possible amount. The upward movement of the gases thru the stack alone produces the draft. Movement laterally increases the friction, hence retards the draft. Consequently, the closer the stack to the kiln, the more this difficulty is avoided.

Best to Insulate Flues.

The insulation of flues from surrounding damp soil is a worth while precaution. It has been estimated that the amount of heat used in the absorption of water from this source by the hot gases where the flues are unprotected is equivalent to from four to ten tons of coal during a single burn.

These losses can be largely obviated by carefully walling, arching and flooring the flues with brick and an impervious mortar, or entirely done away with, by placing the whole kiln upon a concrete base from one to three feet thick.

Where two or four kilns are so located that one large stack will serve them all it is customary to partition the stack flue according to the number of kilns attached to it. These partitions ordinarily run only a fraction of the length of the stack. By this means the stack is made to serve the purpose of so many separate stacks; and as it seldom happens that all kilns attached to the stack are running in the same stage of burn, the draft from one kiln will often aid in starting and maintaining that of another kiln by the union of several flues into one flue above the partitions.

The Purpose of Dampers.

The flow of the draft is controlled by dampers. These may be classed chiefly as slide dampers and valve dampers. Slide dampers may be operated horizontally or vertically. When in horizontal position they are in the stack; when vertical, generally at base of stack in the main flue. Both are commonly made of heavy sheet iron and operated by hand.

An improvement over sheet iron is the fire clay damper, which, when substantially constructed of fire clay tiles fitting into an iron frame, is free from the effects of the hot gases which corrode and warp iron in a short time.

The value of any damper lies in its ability to control the flue it is designed to fit. To do this, all leaks must be avoided and, when closed, the damper should completely cut off all draft. This can be accomplished by making the damper several inches wider than the flue and so arranged that it will work in a notch in the flue walls. If the damper be a vertical one, a depression at the bottom of the flue filled with any finely ground refractory material, fine sand for example, in which it may imbed itself is a great advantage. In general, the horizontal damper tends by its own weight to prevent leakage of the flue gases around it; but when poorly constructed is fully as apt to permit cold air to pass in above it as is the vertical type.

Valve Dampers.

Valve dampers are of two classes, hinged and bell. Hinged dampers may be hinged from the side or at the center. The latter type is exemplified in the ordinary stove pipe damper. It is easily operated, but subject to objections where sooty or tarry gases are encountered. The side-hinged damper is convenient for controlling the drafts in stacks the tops of which are accessible in case the damper gets out of order. It consists of a heavy plate or casting, or it may be built of fire clay, hinged at one side of the top of the stack. To it is attached a lever arm which is operated by a chain or wire from below. The damper is very efficient and can be used on any of the lower kiln stacks.

The bell damper is centrally suspended from above from one end of a lever which may be weighted at the other end to nearly counterbalance the weight of the damper. The damper is conveniently located at base of the stack by a provision in construction by which the turn from the horizontal flue to the vertical stack is made by a step instead of a single right angle. By fitting the edges of the bell damper into slots filled with sand it can be made to cut off all draft when lowered into place, and, in this respect, may be considered one of the best dampers in use.

Relation of Stacks to Draft.

The number of stacks on round kilns varies from one to as many as there are fire holes. It is generally conceded that the draft can be more easily regulated if concentrated in one stack which may be controlled by a single damper. Generally, however, a number of stacks are used in an attempt to properly distribute the draft in different parts of the kiln; these are called multiple-stack kilns, and it is the contention of their designers that each stack can be made to control a definite portion of the kiln, which can therefore have its draft increased or diminished at will without reference to adjacent kiln space. It is evident that this can not be fully realized unless the area which is to draw to a stack be partitioned from surrounding space, when it will of course operate as an individual small kiln. As has been shown, the draft will always set towards and follow the line of greatest heat in the kiln. The kiln chamber may be compared to a vessel filled with a mobile fluid which responds to the action of gravity. Consequently, when a flow is set up thru an outlet in the kiln, the natural tendency is for the gases to rush towards this outlet and the consequent raising of temperature by this act tends to confirm the movement in a given direction. To divert the draft it is necessary to close the damper and allow the gases to seek the next ready avenue of escape. A multiple stack kiln is thus a more or less complicated arrangement to control. It is thus clear that each and every stack will have a uniform draft only when the heat is the same in every part of the kiln, which is difficult of attainment. On the other hand, the conditions of the draft may be so badly overbalanced that the direction of movement will be reversed in one stack, the air flowing down, thru the kiln bottom, and escaping up and out some other stack.

Round Down-Draft Kilns for Common Ware.

The following points may be noted as important in the construction of round down-draft kilns for burning the commoner grades of ware.

For burning brick, which must be very closely set and thus tend to restrict the draft, kiln diameters range from 20 ft. to 30 ft. or more. For wares such as drain tile and sewer pipe, diameters up to 34 and 36 ft. are found. In all cases, however, it is a good general rule to avoid excessive diameters; the less the diameter the better the draft distribution.

The height of the kiln should only slightly exceed the height of the ware stacked in it. Brick are set from 25 to 35 courses high. Six feet is perhaps an average distance from floor to spring of arch, the arch having a rise of four to six feet according to the diameter of the kiln.

The fire holes are advisedly set from two to three feet below the level of the kiln floor; in this manner radiation from the base of bag walls becomes effective in heating ware near the kiln floor. This is the cool part of the kiln and where fire holes are placed on level with floor, radiation is of little importance except from upper half of bag walls. It is usually better to sink the fire holes beneath the ground level than to raise the kiln floor above it, and to surround the kiln with a trench in which the firing is done. The trench is preferably paved with brick, and good drainage provided for. This arrangement also helps to do away with the effects of the absorption of ground moisture.

The number of fire holes ranges from eight to twelve, according to kiln diameter. In general, the number of fire holes is about one-third of the diameter of the kiln in feet. The type of fire box will depend on ware to be burned and character of fuel used.

Stacks.

The stack is placed close to kiln and the flue connections made as shallow as possible. There are some advantages claimed for locating stack in center of kiln. In this position a draft is more quickly started as the stack is heated as soon as the fires are lighted. Naturally, there are no horizontal flues, the radial flues opening directly into the stack. Because the stack is highly heated it is more effective and hence its dimensions need not be so great. The objections to a center stack are the kiln space which it occupies and the cost of construction. It is contended, tho, that the space taken by it, which would otherwise be filled with ware, is only a very small proportion of the whole and its position seldom presents an obstacle in setting or drawing the ware. The stack must be made of fire brick and must have a solid foundation, as it is subjected to the most intense heat of the kiln. The center stack offers advantages in fuel saving and in facility of operation that ordinarily outweigh the disadvantages referred to.

Radial flues are to be recommended and generally number one for each fire hole (the size and openings proportioned as described in an earlier paragraph). A connecting circular flue is sometimes of advantage.

The merits of different styles of dampers have been considered above. For an outside stack, either the horizontal or vertical slide damper can be made to give efficient service if properly constructed. The side-hinged valve damper is also an excellent means of control. With the center stack the latter is the only kind that is applicable. Since the draft is always more vigorous in a center than in an outside stack, the damper that is used must afford a means of accurate and complete regulation. The hinge damper can be well adapted to this instance. (See also several items under Kiln, down-draft, and Kiln, intermittent.)

BUILDERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

396—KILN, INTERMITTENT, UP-DRAFT, PERMANENT.—Permanent up-draft kilns for burning brick, etc., may be round or rectangular in design, but the construction usually permits the direct contact of combustion gases with the ware being burned. The side walls are built permanently instead of being erected as each kiln is set. Sometimes the walls are built the full height of the kiln, but the common practice is to erect them eight or ten feet high and add the necessary new courses as the brick are set. The top is covered with one row or more of burned brick "platting," which is removed when the kiln is drawn. Openings are left in the side walls that lead into arches formed in setting the green brick, and in which the fuel is burned.

Another step in the development of this type of kiln consists of constructing partial permanent end walls and also fire boxes in the side walls. One furnace may feed one or more arches as desired. By this means, the draft is more carefully regulated and the usual spoilage of brick immediately around the arches is considerably reduced. The permanent kiln wall prevents the loss of considerable heat by radiation and assists to make a more even burn than is possible in the temporary kiln, where the outside brick are invariably soft burned and those surrounding the arches are cracked or sagged. (See next item for description of round up-draft kilns, and several items under Kiln, up-draft and Kiln, intermittent.)

BUILDERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

397—KILN, INTERMITTENT UP-DRAFT, PERMANENT ROUND TYPE FOR POTTERIES.—The round up-draft kiln is the early pottery kiln, and is still extensively used in the stoneware industry. The kiln consists of a lower combustion chamber into which the fire boxes are placed, and an upper chamber in which the ware is placed. The combustion chamber occupies nearly all the space beneath the ware chamber, and has a solid bottom, except for the small portion of space occupied by the grate bars of the furnaces. Between the combustion chamber and the ware chamber is fire brick work, perforated to allow the passage of the gases. The gas outlet consists usually of a number of small chimneys leading out thru the kiln crown.

The work of the above kiln is characteristic. When gases are permitted to come into contact with pottery wares in any kiln, flashing is common, since the clays used are sensitive to oxidation and reduction. The degree of sensitiveness varies so greatly, however, that some clays give no trouble whatever, while the ware made from others comes from the kiln with flash marks on it. Glazed wares may show "bluestoning" when burned in this kind of kiln, probably caused by the reducing action of the gases on the iron in the clay. This peculiarity is seldom noticeable in muffle burned wares.

In the development of the modern pottery kiln, the principal changes in this early up-draft kiln have been made to prevent the contact of combustion gases with the ware. To do this "bag walls" are commonly constructed, extending around the whole circumference of the kiln. These bag walls are built to varying heights, in some cases completely enclosing the ware, in other cases being very low. In either event, the gases are more or less separated from the ware, which is heated more and more by conduction thru the walls as they are built to increasing heights. This screening the ware from contact with the flames does away with flashing. If this protection is partial, as where only low walls are used, the construction is called a semi-muffle kiln. If the muffling is complete, as where both walls and center flue unite above the ware and wholly enclose it, the kiln is called a muffle kiln. In all cases, the object is to promote a draft thru the center of the kiln, the ware being stacked so as to leave a center opening, or a permanent center flue is provided.

The consumption of fuel is largely increased by the use of a semi-muffle or muffle kiln, as immediate contact of the hot gases with the ware is cut off; consequently, in order to curtail as much as possible the heat losses by air excess, perfect control of the draft is imperative, and the grates, fire doors, and stack arranged and constructed with this object in view.

BUILDER (see catalog section):
International Clay Machinery Co.

398—KILN, INTERMITTENT UP-DRAFT, TEMPORARY.—Temporary up-draft kilns are commonly divided into the old English clamp and the American scove types. In both types the kiln is built largely of the ware to be burned, but is usually walled and covered with burned brick and bats which are kept mudded-up to prevent loss of heat.

In the English clamp kiln the fuel is first pulverized and then charged in layers with the setting of the brick. Low arches are also constructed at the bottom of green brick and filled with fuel. The fire is first made in these arches and gradually progresses itself thruout the kiln. When all the fuel which has been included in the ware has been consumed, the burning is finished. the effect when the work is liable to ished.

The so-called American scove kiln is similar in construction to the clamp kiln. It differs in operation, however, because the fuel is not included with the brick, but is burned in arches which serve as temporary fire places. This also necessitates a more open setting of the brick, since the heat must be carried thru the ware by air currents. (See also several items under Kiln, up draft and Kiln, intermittent.)

BUILDERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

KILN, MUFFLE, see Kiln, intermittent muffle down-draft, and Kiln, tunnel.

KILN, TERRA COTTA, see Terra cotta, manufacture of.

399—KILN, TUNNEL.—A tunnel kiln is a form of kiln in which the ware moves continually and the fire remains in one place. In many respects this kiln is similar to the tunnel dryer. The tunnel kiln is successfully used for burning sanitary ware, fire brick, furnace blocks, etc. When properly designed it is very economical of fuel, since only one part of the kiln is heated directly, whereas in other continuous kilns each part of the brickwork is heated and cooled in turn. It is also a labor-saver, since the cars can be filled and emptied with great facility, and the control of the firing is all that can be desired. There appears to be no limit to the temperature attainable, there being record of a small tunnel kiln, in regular use for some time, burning refractory brick at a temperature sufficient to bend Cone 17 (1,480 deg. C. or 2,696 deg. F.).

Successful kilns of this type usually consist of a tunnel 300 to 400 ft. long, 3 to 9 ft. wide, and 4 to 9 ft. high, internally, thru which a series of trucks or cars run on rails, the metal work of the cars being suitably insulated from the heat, or the bed may be constructed thruout of refractory material. The fuel may be solid, liquid, or gas; it is burnt in fireplaces at each side of the hottest part of the kilns or in long tubular chambers placed longitudinally in the kiln. The air for combustion is supplied in the same manner as in other kilns, but is supplemented by a current of air which is drawn thru the whole length of the tunnel; this air is heated by the burned goods which are correspondingly cooled thereby, and it is then passed forward with the products of combustion in order to heat the freshly set goods.

In one type of tunnel kiln, the products of combustion are confined to two tubular chambers, but the air in the tunnel circulates round these chambers and round the goods to be heated or cooled.

In summarizing the distinctive qualities of continuous tunnel kilns, Searle says (see "The Clayworker's Handbook," pub. by Lippincott; p. 156) the chief advantages they offer are: (1) The respective parts are always at a constant temperature, so that there is less wear and tear on the kiln-structure than in other types of kilns; this also effects a saving in time and fuel, as the brickwork has not to be heated and cooled. (2) The goods are more easily set and loaded than in other kilns. (3) The saggers, if used, last longer; but in one type of tunnel kiln they are not required and setting is further simplified. (4) The whole of the fuel is used effectively, and there is less loss thru the walls of the kiln. (5) A saving in the cost of brickwork is realized, as only the hottest part needs to be constructed of fire brick. (6) The ground space is less than any other kiln of the same output.

Difficulties in operating tunnel kilns are invariably traced to defective design and construction. Several tunnel kilns of various types are in successful use in this country.

(See also Kiln, insulation and Car, kiln.)

BUILDERS (see catalog section):
American Dressler Tunnel Kilns, Inc.
International Clay Machinery Co.
Rodgers, L. E., Engineering Co.

MANUFACTURERS' ANNOUNCEMENTS:

American Dressler Tunnel Kilns, Incorporated, 1740 E. Twelfth St., Cleveland, Ohio. A Dressler Kiln will burn the equivalent of 100 tons per day or 700 tons per week, burned weight. If brick weigh 4 lbs., this equals 50,000 brick daily; if heavier, then proportionately less.

Time of burn varies from 35 to 55 hours in kiln, depending on nature of clay or shale.

Length of kiln is about 325 ft.; less length if smaller daily production required.

A dryer is always necessary, but the heat for the dryer is provided by the kiln, and in many cases brick can be loaded on the cars at the belt or press, and not thereafter reset.

Natural gas, oil, or coal used in producers for fuel. Burning coal direct is inefficient and expensive.

Kiln cost depends on locality, nature of ground, kind of fuel to be used, etc. Roughly, about $600 per daily tonnage capacity, or for a customary kiln, about $60,000.

To those who are able to satisfy them of their financial responsibility, bankers are ready to advance the money for a kiln and take payments monthly for three years.

You can pay us our profit on these kilns any way you like; per thousand brick or per month, or in one final sum after kiln is running.

We will guarantee performance if you are willing to pay for it.

Can be erected complete in four months' time.

KILN UNLOADER, see Loading machine.

400—KILN, UP-DRAFT, METHODS OF SETTING.—Setting brick in up-draft kilns is a more complicated process than setting in down-draft kilns, and there are probably more methods of setting the former than the latter. Of the known methods there is one little used in this country that has many good points to commend it to the clayworker; it is known as the "tight-bolt" method. In down-draft kilns it is the simplest and fastest of all methods (see description under Kiln, down-draft, methods of setting), and this can also be said of it for setting up-draft kilns, but, in the latter case, the necessity of setting arches and loose heads requires the attention of skilled setters.

The points in favor of the tight-bolt method are: (1) In that part of the kiln where the bolts are set the brick are of more even shade; (2) the setting is accomplished at a faster rate; (3) the faces of the brick are a plain, even, unflashed color; (4) there is no kiln marking; and (5) if the firing is done under reducing conditions, the faces of the brick show a red heart with brown or black ring—a much sought-after result.

As is general with up-draft kiln setting, the legs of the arches are set three bricks wide, with the brick in the center of the legs set in tight, while those on the outside are set as open as possible. When the overhangers are reached, they are set in tight and open courses, as illustrated, and between them the brick are set in regular tight-bolts. Above the brick which close the top of the arches an open course is set—it should, in fact, be as open as possible and still prevent the brick above from breaking under the load.

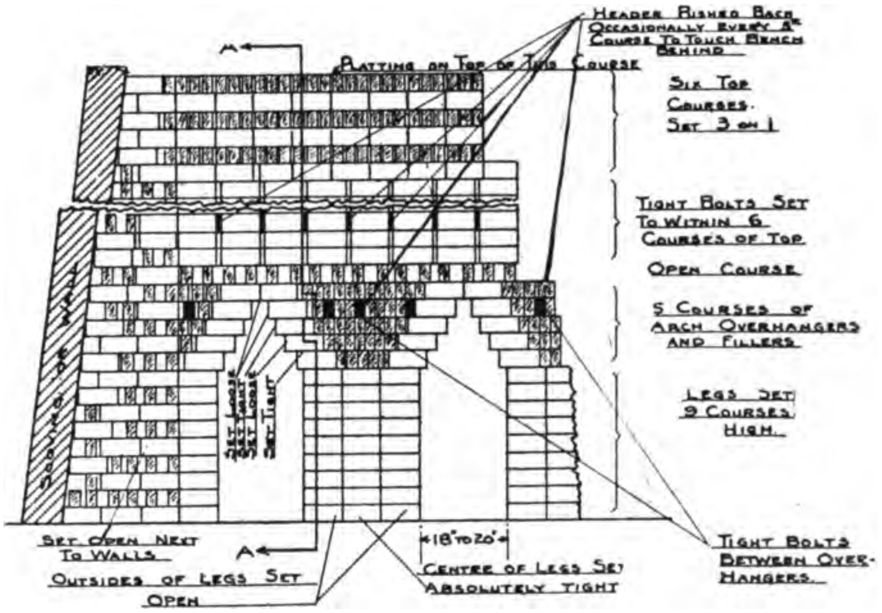

Header Pushed Back Occasionally Every 5th Course To Touch Bench Behind
A
Platting on Top of This Course
Six Top Courses. Set 3 on 1
Tight Bolts Set To Within 6 Courses of Top
Open Course
5 Courses of Arch Overhangers and Fillers
Legs Set 9 Courses High.
Set Loose
Set Tight
Set Loose
Set Tight
Set Open Next To Walls
A
Outsides of Legs Set Open
18" to 20"
Centre of Legs Set Absolutely Tight
Tight Bolts Between Overhangers.

Fig. 1. Detailed Drawing of Setting Showing Method of Building Up the Arches and Laying the Platting on Top. The Section Thru "A-A" is Shown on the Next Page.

Above this course the "tight-bolts" begin and are carried up to within six courses from the top of the kiln.

"Tight-bolts" simply consist of an absolutely tight bench of brick. In looking at this bench it presents a solid face of headers. Each [illegible] set one inch from the [illegible] this 1-in. space being [illegible] of the fire gases. In [illegible] this distance a "follow-board" is used; it consists of a 1-in. plank with two or more leather handles on the top edge. As the bench is carried up, the board is raised up and allowed to rest on a few brick shoved back from the bench which is being set. To prevent the benches from rolling, every fourth or fifth brick in every fourth or fifth course is shoved back until it touches the bench behind. This makes the setting perfectly stable. Care must be taken to carry up the benches perfectly straight.

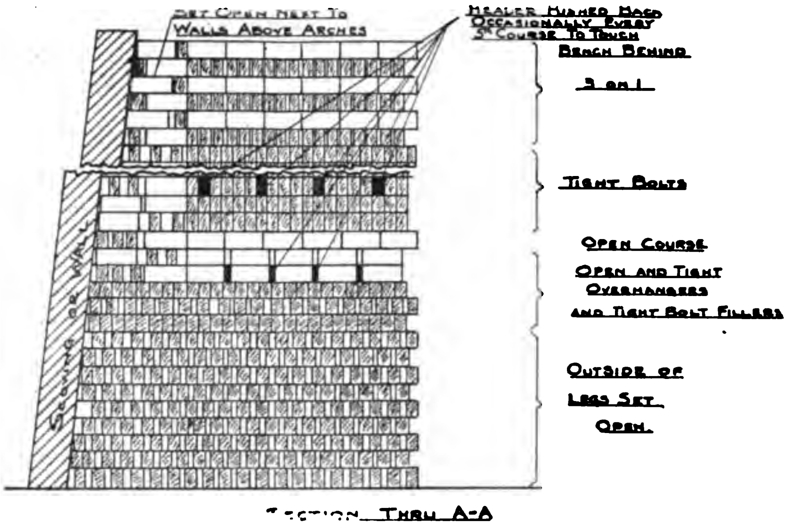

Set Open Next To Walls Above Arches
Header Pushed Back Occasionally Every 5th Course To Touch Bench Behind
3 on 1
Tight Bolts
Open Course
Open and Tight Overhangers and Tight Bolt Fillers
Outside of Legs Set Open
Section Thru A-A

Fig. 2. Cross-Section of Kiln Showing Again How Platting is Laid and the Loose Setting of the Outside Brick in the Arch Legs. This Drawing Also Shows the Solid Face of Headers Present by a Bench of "Tight Bolts."

Facilitates Handling Brick.

This tight-bolt method of setting enables the setter to pick up as many brick as he can handle, drop them on the bench, and push them back against the follow-board.

The brick should be set loose next to the walls in order to pull the heat to this usually backward part of the kiln.

The six top courses should be set three on one, and on top of this the platting is handled in the usual manner.

While the first impression is that the "tight-bolt" method is "impossible," it is being used with success in certain parts of the country, and the average recovery of No. 1 face brick from updraft kilns is well over 50%, even in districts where the brick must compete with the output of modern continuous and down-draft kilns.

401—KILN-WHITE.—A term referring to the white incrustation that forms on the surface of clay ware during burning; caused by the presence of soluble salts in the clay or by the action of sulphuric-acid gas in the kiln. (See Soluble salt; Soluble salt, prevention of; and Barium carbonate.)

KILOGRAM (abbreviated to KILO at times), see Metric system.

L

LACE, BELT, see Belt lacing, all types of, Belt hooks and rivets, and Belt fasteners.

LACUSTRINE, see Clay deposits, classification of and Geological ages.

402—LAMINATION.—This is caused by unequal flow of the clay or unequal pressure or friction. The clay forms into planes which are called "slickensides" by some, and the different planes working at different speeds slide on one another. As a result the bond is weakened or possibly broken and the defects show up as cracks during the drying or burning period. The capillary attraction does not exist as it should between the outside and the center of the ware. When shrinkage takes place the ware does not shrink as one mass, but rather each plane shrinks or tends to shrink under its own influence. The result is that the ware is laminated and not able to stand rigid tests.

Many clays are particularly subject to lamination, but the construction of the auger, die and machine in the case of stiff-mud ware have very important bearings on this subject. It is possible to make these parts so that the very minimum of lamination will be caused. (See also Die, all items; Auger and auger machines.)

LAMP GUARD, see Guard, lamp.

LARD OIL, see Lubricating oil and grease.

403—LATHE, MACHINE.—A machine lathe is a machine primarily for producing cylindrical pieces of metal or wood. In this item we will treat only of the former. It is also adapted for cutting threads on a rod, casting or other piece of metal, and for cutting circular grooves or holes in any piece of metal. The metal to be worked upon is mounted on the head or turret, and care must be exercised to mount it concentrically with the head. Adjustable clamps are provided for this purpose. The head revolves and can be driven at various speeds to suit the work to be accomplished. The cutting tool, which is made of tool steel of the proper shape for each kind of work, is mounted on a frame which moves along the bed. The head spoken of above occupies one end of the bed. Gearing is provided to move the cutting tool lengthwise and crosswise of the bed while the head is revolving. These gears are necessary when cutting threads, and are convenient for any work on the lathe. The cut on a lathe is necessarily circular and any flat surface can be finished thereon if desired, just as on a planer or shaper. The size of a lathe indicates the largest diameter that can be cut in it.

LATHE, POTTERS', see Turning.

404—LAWN.—This term is meant to include the very fine sifting machines used by potters, etc. It is really a regular sifting or screening machine with a very fine screen or sieve, made of flannel or lawn, which is cloth of very fine mesh. The name arises from the cloth used. (See also Wire Cloth and Woven Wire.)

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Mueller Machine Co., Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J. Shaft runs on Timken bearings as well as the cams. Lawn shakes with a double motion which lawns the slip in a very effective manner. Pitch of screen can be set to any angle. It is direct connected to motor with silent chain drive.

LEATHER BELT, see Belting, leather.

LIFT TRUCK, see Truck, lift.

405—LIGHTING SYSTEM, PORTABLE.—Many times, especially in the winter months, outside work must be done before and after daylight. This is true in the pit, kiln setting and emptying, and loading. It is often hard to have an electric light placed at the necessary point, and for this purpose the portable lights used to such good advantage by contractors, are found very serviceable. Several types are manufactured, one using gasoline, which is burned as a gas after being run over a hot surface to turn the liquid gasoline into a gas. Each burner with its tank forms a separate unit and can be taken anywhere. Another type is the carbide or acetylene light which uses calcium carbide and water to produce acetylene gas. The carbide can be dropped into the water but in a portable outfit the water is usually dropped onto the carbide. A very bright white light of great strength and uniformity is produced.

406—LIME.—This ingredient is found in many clays, and may be present in large quantities in low-grade clays. The source of lime in clays is due to minerals belonging to one of the three following groups: (1) Carbonates: calcite, dolomite; (2) silicates containing lime, such as feldspar and garnet; and (3) sulphates: gypsum.

These three groups of minerals behave differently and their effects upon the clays containing them varies greatly.

Lime, however, is considered a deleterious constituent. (See also Calcite, Gypsum; and the item following this.)

MANUFACTURER OF ELIMINATION EQUIPMENT (see catalog section):
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of Patented Deck Sweeper Clay Grinders & Steam Heated Screens for overcoming troubles arising from lime pebbles.

407—LIME-BEARING SILICATES, EFFECT OF.—The effect of these is less pronounced than that of lime carbonate; they contain no volatile elements and hence do not affect the shrinkage to the extent that lime carbonate does. They serve as fluxes (see Alkalies) but do not cause a rapid softening of the clay.

LIME CARBONATE, ITS EFFECT ON CLAY, see Calcite.

408—LIMONITE.—A mineral occurring in clays in a variety of forms, often widely distributed in them, its presence when in a finely divided condition being shown by the yellow or brown color of the material. In some cases it collects in small, rusty grains, or again forms concretionary bodies of spherical or irregular shape. More rarely, it is detected in the form of stringers or crusts, running thru the clay in many directions. The sandstone beds encountered in many sand and gravel deposits associated with some clays are formed by limonite cementing the sand grains together.

Limonite is found in largest quantities in surface clays, especially sandy clays or those which are porous enough to admit the oxidizing waters from the surface. It is also often found in weathered outcrops of numerous shales.

Limonite concretions, if left in the clay, result in the appearance of fused blotches and may even cause the ware to split during manufacture.

The composition of limonite is $2Fe_2O_3$, $3H_2O = Fe_2O_3$ 85.5%, H_2O 14.5%.

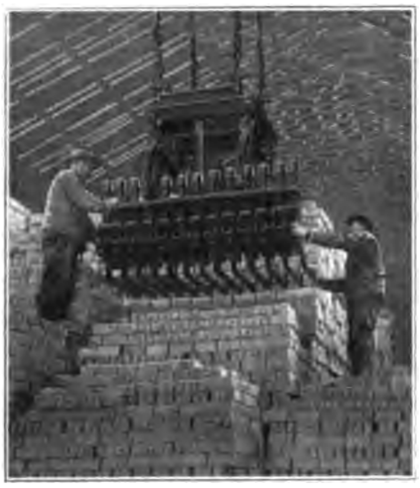
400—LINING.—Potters' term; refers to process of applying a line of color or gold on the ware.

LOADER AND UNLOADER.—See Car unloader; Truck, handpower; Automobile trucks; Truck trailer; Car loaders; Wheelbarrow, and Conveyor, portable and other items.

409A — LOADER, PORTABLE. — In many cases belt conveyors and portable conveyors are used for loading cars, trucks or wagons. These generally consist of attachments that reduce or render unnecessary any labor at that point. They also assist in reducing the breakage to the ware on account of the elimination of handling. The labor of wheeling or carrying burnt ware is always hard and in hot weather may interfere so much with the operation of the plant that production is reduced.

MANUFACTURER (see catalog section):
Link-Belt Company.

409B—LOADING MACHINE.—This is a patented machine used to take loads varying from 750 to 1,000 brick out of the kiln at one operation and deposit them directly in the truck car or barge for shipment. This machine can only be used in connection with the brick setting machine as it consists of a series of long fingers spaced the same as the fingers of the setting machine used in building up the kiln formation. After the brick are burned these fingers are inserted in the interstices left by the setting machine and the same unit that was placed in the kiln is removed. One fork operated by three men will do the work of twenty to twenty-five men.



Machine Handling 1,000 Brick.

This machine when used with the equipment described under the items headed Setting machine, Soft mud brick automatic dumping attachment, and Hacking machine, makes a brick plant thoroly mechanical and automatic. The brick are not touched by any man at any point of the process. The patents on this machine are owned and controlled by The American Equipment Company, 1619 Conway Building, Chicago, Illinois.

MANUFACTURER (see catalog section):
American Equipment Co.

LOCOMOTIVE CRANE, see Crane.

410—LOCOMOTIVE, ELECTRIC, STORAGE BATTERY AND TROLLEY.—The rugged construction and design of the best makes of storage battery locomotives, combined with safety in operation, reduced fire risk, and the flexibility of the track system used, gives them a wide field of application in the clay products industries. Tracks may be run in and out of and around the plant buildings, to the mine or pit, with absolute safety, and there is no smoke or fumes to confuse the workmen when the locomotive enters the plant. Their economic advantages may be summed up in (1) the elimination of hand trucks to a large extent and a decided reduction in labor costs, (2) in the fact that only one man is required to handle the train between the points of loading and delivery, and (3) the ease and rapidity with which 2 to 25 or more tons of ashes, coal, shale, clay, crushed rock, brick, hollow tile and all classes of movable material can be carried in flat or dump cars from one point to another.

The standard track gages are from 20 to 36 ins. Power is transmitted from the motor to the drive wheels usually by a worm drive. In some types, the motor armature and the worm are mounted on ball bearings with a thrust bearing provided for the worm; this constitutes a simple, noiseless, efficient drive. In high grade makes the entire motor is readily accessible, and in some cases may be easily lifted out by merely loosening the bolts of the bracket by which it is supported.

In the motor proper, the design should be such as to embody low internal resistance and low iron loss. The commutator and brush area should be liberal enough to reduce as far as possible loss in the brushes and brush contact. The motor should always be capable of efficient operation in pulling both light loads and temporary very heavy overloads.

The construction of the journal boxes should also be such as to prohibit an excessive lateral action of the locomotive body. Lubrication is likewise a vital factor and all moving parts must be kept properly oiled and greased, if burnt-out journals and excessive wear are to be avoided.

The capacity of an electric storage battery locomotive is generally expressed in ton-miles. For instance, a 5-ton locomotive may be guaranteed to haul 300-ton miles before the batteries require to be recharged. The capacity of the battery is determined in kilowatt hours. A simple formula to learn the kilowatt hours required of a battery for a given duty is to multiply the tractive effort by the distance in feet by .00000063. For example, assuming that the battery must haul a gross weight of 40 tons, including the weight of the locomotive, for a distance of 2,000 ft., and that the track-resistance is 30 lbs. per ton, then $40 \times 30 \times 2000 \times .00000063 = 1.512$ K. W.-hrs. Under average conditions, a 20% increase of battery capacity should be allowed to take care of the switching which the locomotive is usually called upon to do at the terminals of the haul.

Where the storage battery locomotive is to be exposed to and operated in varying weather conditions, precautions should be taken to protect its vital operating mechanism as much as possible.

The Industrial Trolley Locomotive.

This type derives its current supply from an overhead feed system, the source of which may be a local power station or a public utility station. The low cost of current, wherever public service is available, generally precludes the erection of an isolated plant. The simplicity and ruggedness of construction and economy of operation that mark the storage battery locomotive are practically duplicated in the trolley type. The fire risk is somewhat increased, as is the liability of personal injury from the overhead trolley system where the locomotive runs in and out of the plant; but on long hauls in conveying raw materials from the mine or pit to the mills, the trolley system is probably the more economical and reliable over long periods of continuous operation.

MANUFACTURER (see catalog section):
Whitcomb, Geo. D., Co.

MANUFACTURERS' ANNOUNCEMENTS:

Geo. D. Whitcomb Co., Rochelle, Ill. Whitcomb locomotives are made in various types, including gasoline, storage battery and trolley drive, in sizes from 2½ to 25 tons. We make a specialty of locomotives designed and equipped for quarries and brick yards.

411—LOCOMOTIVE, GASOLINE, INDUSTRIAL.—The gasoline locomotive, like the automobile, is propelled by an internal combustion engine. Its design especially fits it for work in contracting operations, quarries, brick yards, etc., where loads are to be hauled at moderate speeds within the available range of powers. Being self-contained, the radius of the gasoline locomotive is limited only by the capacity of the fuel tank carried. In localities where water is scarce or where the cost of coal and electricity makes the operation of electric or steam locomotives practically prohibitive, and in isolated places with no power supply, the gasoline locomotive offers the advantage of requiring no power house installation or special track equipment.

Gasoline locomotives are usually supplied in four standard sizes, weighing 3½, 5, 7 and 9 tons, respectively, this range being sufficient to meet average industrial service requirements. The average standard speeds are five miles per hour on low gear and ten miles per hour on high gear, forward and reverse. Running under normal or rated load, the consumption of gasoline is 0.10 gal. per horsepower per hour. Observations conducted by one manufacturer indicate that for most requirements the fuel consumption may be based on an average development, thruout the working day, of one-half the rated horsepower.

In general, the design of gasoline locomotives follows the logical development of steam locomotive practice, without sacrificing such important features as convenient arrangement of parts, accessibility, or ease of control and operation. All control levers are kept in easy reach of the motorman, who is usually stationed under a canopy fixed over the rear of the locomotive. The engine is also conveniently positioned for constant supervision and minor adjustments while running, without leaving the cab.

Different methods are employed by different manufacturers to transmit power to the drive wheels, the usual worm drive with spur thrust, differential gearing with chain drive or friction drive being applied as best suits the individual design. In all makes, however, the transmission is essentially one of the most important features of the locomotive, and all gears, shafts, clutches and accessory parts should be liberally proportioned, carefully protected by housing, and an efficient lubricating system provided thruout.

Self-starters are practically indispensable to the 7-ton and 9-ton sizes, which are extremely difficult to start by hand, especially in cold weather. The motor for the self-starter receives its current supply from a storage battery, and this, in turn, is charged from a generator driven by the main engine; this charging of the battery is automatic and requires no attention from the operator.

MANUFACTURERS (see catalog section):
Brookville Truck & Tractor Co.
Easton Car & Construction Co.
Hadfield-Penfield Steel Co.
Whitcomb, Co., Geo. D.

MANUFACTURERS' ANNOUNCEMENTS:

Brookville Truck & Tractor Company, Brookville, Pa. The Ford Worm Drive Ton Truck, applied to gasoline locomotive haulage thru use of Brookville attachments. Power unit practically intact, plus Brookville Auxiliary Reverse Transmission, giving motor the Ford ton truck high and low speeds as well as the same pulling power in forward or reverse. Economical, both as to first cost and operating cost. Powerful, and extremely speedy in operation. Practically all the advantage of local Ford Service at the command of user. Will handle from two up to twenty tons to train, depending on track and grade conditions. The most practical, efficient, and economical light gasoline locomotive available today. Submit your haulage details to us. If we can handle we can show a saving over any other power on the market.

MANUFACTURERS' ANNOUNCEMENTS:
Geo. D. Whitcomb Co., Rochelle, Ill. Whitcomb locomotives are made in various types, including gasoline, storage battery and trolley drive, in sizes from 2½ to 25 tons. We make a specialty of locomotives designed and equipped for quarries and brick yards.

412—LOCOMOTIVE, STEAM.—The power in a steam locomotive is derived from a boiler and steam engine. In industrial work the gage of the track is usually 24 or 36 ins. The use of locomotives to haul cars of overburden to the spoil bank, or to haul cars of clay to the plant, has been found to effect a large saving over the use of horses or mules, unless the output is small. The boiler is of the locomotive fire box type, that is, one in which the water in the boiler surrounds the fire box on the side, and the tubes are directly ahead of the fire and horizontal. The engine is of the regular locomotive type. The steam can be made by using wood, coal or fuel oil for fuel. The steam locomotives are made in various sizes based on their weight. A 15-ton locomotive is rated to haul the following loads, in addition to its own load up the different grades: 1% grade, 95 tons; 2% grade, 53 tons; 3% grade, 35 tons; 4% grade, 24 tons; 5% grade, 19 tons; 6% grade, 14 tons; 7% grade, 10 tons; 8% grade, 8 tons. This includes the weight of the cars and the material in them.

LOESS, see paragraph headed common brick clays in Clay entry.

413—LUBRICATING OIL AND GREASE.—Under this heading we place all of the numerous oils and greases used for lubricating, that is, used to form a thin film between two surfaces in order to reduce the friction. These are principally made from mineral oil or petroleum. In a few lubricants, such as castor oil, vegetable oil forms the base. Oils and greases are made of various consistencies and weight to suit different purposes. Cylinder oils for steam engines are the heaviest class, and they are made in several grades to lubricate at different temperatures. An oil to use with superheated steam is more expensive than one to use with saturated steam of low pressure, but if used with the saturated steam and low pressure may not give as good service as when used under the more severe conditions. Somewhat similar conditions prevail in regard to engine or machine oil. If the bearings are fairly tight like they should be on a steam engine, the oil should flow freely in order to get between the shaft and bearing. On the other hand, if the bearings are loose as they sometimes are on car wheel bearings, a thin oil will flow away with little lubricating effect. It is very much like clay products, each variation of the products is made for a special service and will give better satisfaction in that service than it would anywhere else or than any other oil or grease will give in that particular service. In lubricating dies there are special oils that are made for that service entirely sold under the name of brick machine oils. Automobile cylinder oil is also made in several grades principally on account of the variations in the weather. In the case of all oils that are used in connection with heat such as the steam and automobile cylinder oils the main consideration is that they will lubricate at the temperature desired and still not leave any carbon or deposit after doing their work of lubrication.

Black oil is a low grade lubricant, suited to be used in the bearings of mine, pit and dryer cars, and also in some shaft bearings. Its lubricating qualities cannot be compared to the better grade of oils such as engine and machine oils, but on account of its low cost it is often a cheaper oil when the proper conditions exist. It is thicker than machine or engine oil, and therefore better suited where there is liable to be waste or the bearings do not fit tight enough to hold the lighter oil or where the speed is low. If used where the better grade of oil is needed black oil is liable to gum and stick up the bearing and also permit it to get overheated.

Black oil is usually sold in two grades, summer black for use in warm weather and winter black for use in cold weather. The latter is thicker than the former.

Lard oil is a lubricant expressed from chilled lard. Lard oil is used mixed with varying amounts of kerosene as a lubricant in represses on cutters and other places where clay moves on iron or similar substance. On account of its cost lard oil has been superseded in great measure by brick machine oil.

Greases are also subject to the same selection, as a heavy grease will be suited to a bearing that is located in a warm place or one that is subject to variation in load and thereby may get warm at one time or other, whereas a light or thin grease may run away due to the heat after doing little or no lubricating. Graphite is often mixed with grease to assist as it is a very good lubricant.

LUBRICATION, see Lubricating oil and grease; and Graphite.

414—LUBRICATOR, SIGHT FEED AND PRESSURE FEED.—A lubricator for engine or pump is either sight feed or pressure feed, altho both are really pressure fed. A sight feed lubricator, so called, is one in which the lubricating oil is stored in a small tank of a capacity of a pint or quart or thereabouts. Steam from the main line is led into this tank and the pressure of the steam forces the oil thru a small opening into the steam line just above the cylinder to be lubricated. In its passage from the tank to the steam pipe the oil passes thru a glass tube containing water, and as the oil can be seen at this point, the lubricator is called a sight feed lubricator. A pressure feed or force feed lubricator is one in which a small pump or plunger takes the oil out of the storage tank and pushes it into the pipe just above the cylinder, or into the cylinder itself. Some of these pressure feed lubricators are equipped with sight feed devices, so that the main difference between the two types is that one uses steam as the forcing medium and the other a small pump or plunger.

415—LUSTER WARE.—This ware was manufactured by the Egyptians, Greeks, and Romans from about 600 B. C. to 300 A. D., when it was discontinued entirely and was not revived until the 19th century. The original composition of the luster is even now still doubtful, but the body is made of a clay sometimes moderately plastic and ferrugino-calcareous (Greeks and Romans), and sometimes decidedly silicious (Egyptians). Being a form of terra cotta, the ware is turned and finished, the burning, which is usually at a low temperature, and sometimes oxidizing, giving products of a color varying from yellow to bright red; when reducing conditions prevail, they give the body a gray tint. Because of the soft nature of the body of Egyptian luster ware it could be polished, carved, and even painted or varnished. The green shades of Egyptian pottery were produced by oxide of copper. The analysis of black luster has only shown iron oxide, sometimes mixed with a little manganese oxide in a proportion quite insufficient to produce a black color. There are many interesting features concerning this ware of which modern practice is still ignorant or doubtful.

Luster decorations may be applied to pottery by two methods: first, by applying in paste condition suitable metallic salts to the surface of the ware, such as tin and antimony, and firing at a dull red heat; second, by vaporizing such salts in the flame of the kiln in which the ware is placed. The latter method is productive of iridescent effects similar to that of favrile glass. An investigation of lusters for pottery decoration has been made by the Bureau of Mines to determine the most suitable glaze composition for taking vapor lusters. Results indicated that glazes containing B_2O_3 and PbO produced the best luster effects, the intensity of the luster increasing with larger amounts of these two components in the glaze. (See also Ceramics, a brief history of.)

M

MACHINE OIL, see Lubricating oil and grease.

416—MAGNESIA AS PIPE COVERING.—Magnesia is used as one of the principal ingredients of pipe coverings, because of its extremely light weight. Any material that is light contains a large percentage of confined air, and it is well known that nothing assists in insulation as does confined air. Magnesia is mixed with glue to form a plastic compound for insulating valves, pipe fittings, etc. In the prepared pipe coverings on the market, magnesia is mixed with some light fibrous material molded into the desired shape and covered with canvas. (See also Pipe Covering.)

417—MAGNESIA, ITS EFFECT IF PRESENT IN CLAYS.—Magnesia, that is, the oxide of magnesium (MgO), is very seldom present in clays to a greater extent than one per cent, unless we consider magnesite and dolomite as clays. When burned, magnesite becomes magnesia (MgO), and is highly refractory, but when present in small quantities with other fluxes magnesia acts as a flux, making the clay soften slowly instead of quickly as occurs with a clay that contains a high percentage of lime. The presence of magnesia in fire clay is especially serious, as it helps to reduce the melting point.

MAGNESITE BRICK, see Dolomite and Magnesite.

MAGNETIC SEPARATOR, see Electro-magnetic purifier.

418—MAGNETING.—A term which refers to the use of electromagnet machines, by means of which particles of iron are extracted from the clay slip before it flows into the smooth agitator, as one of the preliminary stages of preparing clay for the manufacture of pottery. (See also Electromagnet purifier.)

419—MAGNETITE.—The magnetic oxide of iron (Fe_3O_4); forms black magnetic grains; usually found only when material is examined with microscope. On exposure to air or in presence of moisture, it changes to limonite.

420—MAJOLICA AND FAIENCE.—These terms are rather loosely used, but faience is generally understood to be pottery in which the colored clay body is covered with a clear glaze, and majolica to be pottery in which the colored clay body is covered with an opaque enamel. (See also Faience.)

421—MANGANESE.—A black mineral used in the form of the oxide. It is used principally to color the face or body of face brick, terra cotta or other facing material. Low grade fire clay makes a good foundation for the use of manganese as the black spots caused by the manganese make a better contrast on the buff clay than on a redder burning clay. Manganese is sold in several sizes, the smaller ones to produce a gray brick and the larger sizes to make spotted or mottled brick. Some very nice combinations can be produced by selecting the right grade of raw material and the proper size of manganese.

422—MANGANESE OXIDE.—Occurs in quantities up to 1% in many clays. In some residual clays the manganese may appear in quantities worth collecting.

423—MANGANESE STEEL.—The name given to steel castings which have a certain percentage of manganese in them. This results in a very hard casting, and its use is advisable for any of the places where the hard service found in a clay products plant necessitates frequent renewal of castings, such as augers, pan plates, gears, mixing, pug-mill knives, mullers, and crusher parts.

MANUFACTURER (see catalog section):

Hadfield-Penfield Steel Co.

424—MANGLE, DIPPER'S.—A device used in the manufacture of white goods in potteries which provides a means of drying dipped ware. The mangle consists of a rectangular chimney, say, 60 ft. high, 7 ft. long, and 4½ ft. wide. It is fitted inside with two shafts, one at the top and one at the bottom, each shaft carrying two sprocket wheels over which run two endless chains. From these endless chains are hung boards, 5 ft. long, studded with nails of various lengths, on which the ware is placed by the dipper. The dipper works thru an opening at the bottom of the stack, placing the ware upon the boards while they are in motion. In this manner the ware is taken from him, passed thru the heated chamber, and delivered on the opposite side to the attendant, perfectly dry. The inside of the stack is fitted with a suitable steam coil. In heating, the chief advantage to be gained by use of the mangle is that the ware is not touched while the glaze is still wet upon it. Thus, the edges of the ware are protected and come from the kiln more perfectly glazed.

MANUFACTURER (see catalog section):

Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

MANUFACTURERS' ANNOUNCEMENTS:

Philadelphia Drying Machinery Co., 3351 Stokley St., Philadelphia, Pa. Build various standard sizes of Automatic Mangles. Used for all kinds of dipped ware. Steel construction, asbestos insulation. Efficient heated-air recirculation system. Automatic temperature and humidity apparatus used when desired. Produces uniform ware, at low cost.

424A — MANOMETER.—This instrument is the indicating part of a draft gage outfit. It consists of a V tube that has one end connected with a pitot tube in the flue or stack whose draft is to be measured.

The other end is partly filled with mercury and the draft is measured by the variations in the level of the mercury due to the reduced pressure caused by the draft.

425—MAPS.—In laying out any intensive sales campaign, a map of the district to be covered is very beneficial, as the lines of communication and the possibilities of business are shown very forcibly. Maps are mounted on pasteboard and hung on walls, but if several are in use they should either be placed in a rack of drawers, or mounted vertically around a central standard, so that one can be studied at a time. Pins are used to a great extent for certain indications on a map, and may have any number of different kinds of heads. One color or type of head may indicate the locations of dealers, another live prospects, another the business that was obtained by a competitor, another orders that have not been shipped complete, etc. There is no limit to the possibilities of the development of the use of these maps and pins. The territory for one salesman can be laid off by stretching cord or string around the pins on the outside of his district. The freight rate to a certain point or district can be shown by a certain color of pin.

MARINE BEARING, see Bearing, ordinary types of.

MATERIALS, BUILDING, see Supplies for building construction.

MECHANICAL BRICK SETTER, see Setting machine.

MECHANICAL WHEEL.—A form of jolly or jig, see Jiggering and jollying.

425A—MESH.—This term is used in several ways around a clay products plant. In speaking of the holes in a perforated sheet steel screen it means the diameter of the hole if the hole is round, for instance, No. 6 mesh in a round hole means that each hole is one-sixth of an inch in diameter. In a piano wire screen or a wire cloth or woven wire screen the mesh means the number of openings to an inch. In these cases the thickness of the wire has an effect on the opening, for instance, a screen of No. 6 mesh may use wire that is .036 in diameter. In that case the opening between the wires is about ⅛ inch. If this same screen used wires of .065 diameter the opening would be reduced to about .10 inch.

In talking of gears mesh means the proper location of two gears so that the teeth will wear a minimum amount.

METAL, ANTI-FRICTION, see Anti-friction metal.

METAL, BABBITT, see Babbitt metal.

METAL HOSE, see Hose, metal.

METAL, PERFORATED, see Perforated sheet metal.

METER, DRAFT, see Draft gage and meter.

426—METER, WATER, GAS, ELECTRICITY, STEAM, ETC.—A meter is a device to measure the flow of a liquid, gas or electricity as it passes a certain point. An indicating meter is one that shows the total amount that passes. This is shown on a series of small dials. The usual water and gas meters are of this type. In electricity the volt-meter shows the voltage of the current and the ammeter the amperage of the current. The meter used to measure current used is a watt-meter, as a watt is the standard of power in electricity. Watt-meters are made either indicating or recording. A recording meter is one that makes a record on paper of the flow of the force or material at that point every moment. Steam meters are both indicating and recording, and for a steam line a recording gage is far more serviceable, since it shows the amount of steam used every moment and prints or traces this record on paper. Boiler meters are recording instruments that show on paper the rate of steam flow, the air flow to the furnace, and the flue gas temperature. Another form shows the amount of steam produced by each pound of coal burned. When using powdered coal, as in connection with stokers, a coal meter will register the amount used. Oil meters are usually made like water and gas meters, simply to indicate or register the total amount that has passed the meter.

426A—METRIC SYSTEM.—The metric system is the system of weights and measures in which the divisions are all multiples or divisions of ten of the unit, the same as our system of money. The metric system is used extensively in Europe and in scientific calculations. The metric unit of length is the metre—39.37 inches. The metric unit of weight is the gram—15.432 grains. The reader is referred to the statistical section for tables for converting metric measures into standard American measures and vice versa.

427—MICA.—The micas are silicates of alumina and iron and the alkalies, and commonly contain magnesia. Some species of mica is found in most clays, and it is one of the few minerals in clay that can readily be seen with the naked eye, for it exists commonly in the form of minute scale and plates whose bright, shining surface makes them conspicuous, even when small. Mica is very slowly affected by weathering conditions. Because they contain a higher percentage of alumina, the micas do not fuse as readily as feldspar, but are nevertheless active fluxes at slightly higher temperatures. The presence of micas is detrimental to the color of a light burning clay, because of the small percentage of iron they usually carry. The percentage of mica in clays, however, is seldom large enough to be harmful.

Mica is a good electrical insulator and hence is used a great deal in the manufacture of armatures for motors.

MILLIMETER, see Metric system.

MINING CLAY, see Clay winning.

427A—MINING, HYDRAULIC. — This method is used in Cornwall, Eng., in mining clay of great depth. First a shaft is sunk in the solid rock near the clay to be worked. A tunnel is then run from the bottom of the shaft to the clay ground. The end of the tunnel in the clay is connected with the surface by a small vertical shaft. A stream of water from a hydraulic gun is turned onto the material containing the kaolin and being very fine grained it is taken up and held in suspension by the water. The milky liquid is allowed to flow down the shaft, along the tunnel and finally is raised to the surface by means of a pump.

MIXER, CLAY, see Feeder and mixer, clay.

MOLDING, POTTERY, see Casting, Jiggering and jollying, and Pressing.

MOLD-MAKING, see Potters' molds.

428—MOLD SANDER.—In the manufacture of soft mud brick, the molds must be sanded. In order to do this cheaper and more efficiently, a class of machines has been put on the market called mold sanders. At times they are consolidated into a soft-mud machine and form a part of it. The empty mold is fed into one side of the machine, and comes out at the other with all of the inside evenly sanded and the surplus of sand knocked off. Sand is used so that the clay of which the brick is made will not stick to the mold, and therefore the brick will not be misshapened when dumped out.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.

429—MOLDS, MISCELLANEOUS TYPES OF.—The molds for making the different classes of clay products are of many types, because the mold is the box or form which determines the size, shape and form of the finished piece of clay ware. For the repress of a plant making brick of any kind the molds must be of tool or other hard steel. The molds for soft-mud brick are made of either wood or steel. Special shapes of fire clay are made in wooden molds sometimes lined with metal. Plaster of paris is used for terra cotta and pottery. Most other shapes are made in metal molds, altho when the shape is odd or the quantity small, wood or plaster of paris is used.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.

430—MOTOR, ELECTRIC.—An electric motor is a machine or device for converting electrical energy into mechanical energy; in this, it functions oppositely from generators and alternators which are used to convert mechanical energy into electrical energy (see Generator and alternator). The construction of a motor, however, is identical to that of the generator or alternator. The use of motors to drive each machine individually has grown rapidly in the clay products ~~industry~~ in recent years. An individual motor applied to each machine eliminates the danger and expense incurred by driving from a lineshaft; it also economizes floor space, and has the advantage of not consuming power except when in actual operation. Isolated machines, such as pit pumps, coal unloaders, etc., can be easily and economically driven by a motor. Electric motors are now furnished in practically any size desired, usually from ⅛ h. p. up, and for either alternating-current or direct-current circuits.

MOTOR OIL, see Lubricating oil and grease.

MOTOR TRUCK, see Automobile truck.

MOVER, CAR, see Car mover.

MUFFLE KILN, see Kiln, intermittent, muffle, down-draft.

431—MULLER.—These are the heavy grinding wheels of a dry or wet pan, and are used in each case to grind the material finer. In the case of a wet pan they are used to temper or toughen the mix in addition to grinding. A muller consists of a heavy rim which fits around the center part of the wheel. This center is fitted with a hub which must be provided with proper lubricating oil or grease so that it may rotate on the shaft when the revolution of the pan causes the muller to rotate also. This center may be solid or hollow, depending on whether or not it is desired to have a heavy or comparatively light muller. The outside rim is made of chilled iron, cast steel or manganese steel and may be from four to eighteen inches wide and from four to twelve inches thick. Changing a muller is often a big job and in fact sometimes it is found that replacing a muller tire that has worn unevenly means replacing the muller plates; that is, the plates on which the muller travels or grinds. Even when mullers are in continual use they wear unevenly unless made of hard material, and this uneven wear reduces the capacity of the pan in direct proportion to the amount of spaces or surfaces that are worn so much that they do not touch. We have, therefore, three causes for loss due very often to making the mullers out of material that is too soft, the reduced production during a large part of the lifetime of the muller, the cost of the labor and material for putting on a new tire, and the cost of the lost production during the time of repair and replacement. It would be well for all clayworkers, therefore, to seriously consider the use of harder metals for the tires and bed or muller plates of their dry and wet pans, as cost systems will show in a great many cases that the more expensive material is the more economical. This description of the use of mullers also applies to chaser mills as they are a form of wet pan. (See also Chaser mill; Pan, dry; Pan, wet.)

MANUFACTURERS (see catalog section):

Eagle Iron Works.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Stevenson Co.
Toronto Foundry & Machine Co.

N

432—NACRITE.—A mineral related to kaolinite, and said by Johnson and Blake to be identical with pholerite.

433—NARROW GAGE TRACK.—The industrial track used around a clay products plant is called narrow gage because the gage or distance from rail to rail is less than that used on the standard railroad track. Narrow gage track is usually made 24, 30 or 36 inches wide. (See also Frogs, rails and switches.)

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.

434—NEWTONITE.—A rhombohedral mineral which appears in soft, compact masses, resembling kaolinite; color, white; sp. gr., 2.37. Its composition is: silica, 38.5 parts; alumina, 32.7; water, 28.8.

NON-PLASTIC MATERIALS, see Clay products manufacture, non-plastic materials of.

435—NONTRONITE.—A mineral, said to be the ferric equivalent of kaolinite; probably occurs in some clays but is rarely referred to or identified. It is easily decomposed by acid or alkaline solutions, and yields limonite as an ultimate product of aqueous action. Formula, $H_4Fe_2Si_2O_9$.

NOZZLE, see Sleeve, nozzle and runner-brick machinery.

O

436—OBSOLESCENCE.—Obsolescence is that phase of accounting which aims at arriving at the loss of value of machinery, land, buildings or equipment due to the fact that the object in question has become out of style or that improvements have been made by which a competitor can produce better or more economical ware. A machine purchased ten years ago may be in very good physical condition, and may make as good ware as when new, but if a competitor can buy a new machine that will produce better ware or equally good ware at a reduced cost, it is poor business to use the old obsolete machine. In accounting obsolescence must be estimated to a large extent, and it is necessary to consider it wherever the equipment must be replaced sooner than indicated by the rate of depreciation. (See also Depreciation.)

437—OFFICE EQUIPMENT. — In addition to the usual desks, chairs, etc., found in an office, there are many conveniences, machines, pieces of equipment, etc., that greatly increase the efficiency of the work, and reduce the cost of doing the work. Included in this classification are typewriters, adding and calculating machines, filing cabinets and systems, check protectors, loose leaf and machine bookkeeping systems. (See also Card indexes; Maps; Charts, graphic, etc.; Safes; Vaults; Clock; Clock, watchman's; and Accounting.)

437A—OIL AND GREASE.—In addition to the oils and greases described under Cat oil; Lubricating oils and greases; Fuel oil; and Fat oil, we have other oils for special purposes, such as cutting oil which is a compound to use in a machine shop for work around the lathe, drill press, power hack saw, etc. It is an oil made especially to enable metal to be cut without heating too much. Any cutting of metal is accomplished with the expenditure of heat and this oil is made to reduce the friction of the two surfaces as much as possible and also to lower the resultant heat as far as possible. In making flower pots a special oil is mixed with the clay which lubricates the flower pot as it is being formed. This oil burns out as soon as the temperature is raised in the kiln. One of its main requirements is that it must not discolor the ware.

438—OIL BURNER.—In using fuel oil for operating boilers or a kiln, it is necessary to have some burner which will insure the utmost economy. Fuel oil cannot compete with other forms of fuel if this utmost economy is not attained. There are two methods of mixing oil for proper combustion, one is to heat the oil to such a degree that it will volatilize and then burn as a gas, and the other is to atomize the oil; that is, break it up into small particles surrounded with air for the combustion. In this latter method the atomizing of the oil is accomplished by steam or compressed air. Some of the heavy oils are hard to atomize and 15 or 20 pounds pressure is necessary to accomplish the result. The installation for the compressor plant of this size is costly and in the operation there is a large amount of noise, so that a combination high and low pressure burner has been devised and works satisfactorily. The oil is fed under a pressure of 15 to 25 pounds and a small amount of steam or compressed air is used to atomize it at a slightly lower pressure. The air for combustion is supplied at four to six ounces. One of the big advantages of this type of burner for a clay products plant is that it is very easy to attain an excess of air which is necessary in the water-smoking stage of the burning, the exact proportion of air for complete combustion which is necessary when the heat is being raised, and a deficiency of air at the completion of the burn if reducing conditions are desired. These changes can be made by regulating the amount of air entering thru the low pressure line, while the oil feed and the air or steam for the atomization are kept in proper proportion, and can be regulated according to the amount of fuel desired.

MANUFACTURERS (see catalog section):

American Equipment Co.
Hadfield-Penfield Steel Co.
Weller Manufacturing Co.

439—OIL, CAT.—A mixture of mineral and other oils of varying composition, used largely in the lubrication of clay in brick-making. Creosote oil, cheap emulsions, and oily waste products are largely used for this purpose because of their cheapness, altho it is much better practice and less costly in most cases to use an oil or emulsion of superior lubricating power and to control its application so as to prevent wastage.

440—OIL CUP, SIGHT FEED. — A sight feed oil cup is one which enables the operator to see the oil as it feeds from the reservoir to the bearing. The size of the oil cup depends on the size of the reservoir. At the bottom of the reservoir a needle valve is placed and arranged so that it can be locked in any position desired, to feed a definite number of drops of oil per minute, and also can be closed at any time to prevent any oil feeding. Between the oil reservoir and the bearing there is a short glass tube thru which the oil drops and the metal is cut away so that the operator can view the drops. An oil cup of this type can be screwed into a bearing or into a pipe. Many of the force feed and gravity oiling systems for machinery use this sight feed feature in their piping without an oil cup. A thin oil must be used in the ordinary sight feed device. (See also Oiling system; Lubricating oil and grease.)

OIL ENGINE, see Engine, internal combustion.

441—OIL, FAT.—An oil obtained by the evaporation of turpentine at low temperatures, and used in overglaze painting. It is more greasy and adhesive than turpentine, and somewhat pleasanter to use.

442—OIL FILTER AND PURIFIER.—It is well known that lubricating oil which has been used only once has not given up its full lubricating efficiency. Oil consists of infinitesimal particles which resemble ball bearings. When it is used for lubrication most of these particles are broken up and that part of the oil rendered unfit for further lubricating service. Some of the oil, however, passes without being affected. To recover this unaffected oil, filters and purifiers are installed. Several types are used but the object and the result of each is the same; namely, the separation of the used and unused oil. The former is discarded and the latter mixed with the fresh oil. Where plants are large enough and a large amount of oil is used, the oil which is recovered pays a large interest on the cost of installation and operation. In order to filter oil, some method of gathering the used oil must be employed. This is easy with a machine or engine using the splash or forced feed system, or where a reservoir of oil is kept below the bearing as in a ring or chain system of lubrication.

OIL, FUEL, see Fuel oil.

443—OILING SYSTEM.—In addition to sight feed oiling cups which are described under an item of that heading, there are oiling systems that force the lubricating oil into the bearings. This type of lubrication is very satisfactory for engines, auger machines and any machine that has a number of bearings that must be oiled thoroly at all times. A small pump of some kind is usually connected to the machine so that the lubrication starts and stops with the operation of the machine. The oil is forced by this pump into the several bearings, and often the pipes leading from the pump to the bearings are equipped with sight feed devices that show whether or not the oil is going to each bearing. This system is very satisfactory as there are always distractions and troubles that tend to cause a man to neglect lubrication, for a short period, and at times this neglect becomes serious.

OILLESS BEARING, see Bearing, oilless.

444—OIL, PRINTER'S.—A sticky, adhesive medium used as a vehicle for the color applied in underglaze decorations by means of printed transfers. Ordinarily it is made by one of the two following recipes: (1) To 1 gal. of linseed oil, boiled for three hours and then scummed, add 30 oz. Stockholm tar, 1 oz. red lead, 1¼ ozs. rosin, and boil well, skimming carefully. (2) Boil a mixture of 2 qts. of linseed oil, 1 pt. rape oil, and 1 oz. red lead for two hours. Allow mixture to cool somewhat, then add 2 ozs. of sulphur and a trifle more than ½ pt. of common tar, stirring well together.

Searle's Ceramic Industries Pocket Book gives the following recipe for printing oil:

Linseed oil	48 ounces
Wood tar	3 ounces
Colophony	1 ounce
Red lead	1 ounce
Flowers of sulphur	1 ounce

These materials are heated while being stirred until a uniform liquid is produced. Printing oil of good quality rapidly becomes "tacky" when a drop of it is placed on a piece of unglazed ware. It is usually preferable to purchase printing oil ready for use from a reputable dealer.

OIL SEPARATORS, see Separator, oil, steam, etc.

446—OIL STORAGE SYSTEM.—On account of the fire hazard, and also on account of the necessity for eliminating all waste, a proper oil storage system has attracted the attention of all up-to-date plant managers. Fuel oil is usually stored in large underground tanks, holding a carload or more. Underground storage is also very advisable for gasoline, and to a certain extent for kerosene. Lubricating oils of the various kinds should be pumped from the containers in which they are purchased into tanks of various sizes, so that they can be pumped from these tanks when it is necessary to use them. The use of tanks and pumps reduces and almost eliminates the danger of oil being wasted. These tanks are usually made of quite heavy sheet iron, and the pumps are similar to those used for selling gasoline in up-to-date filling stations.

OPERATION RECORDER, see Recorder, time and operation.

ORSAT APPARATUS.—Apparatus originated by Orsat for flue gas analysis. (See Flue gas analysis apparatus.)

446A—ORTHOCLASE.—A form of feldspar for which the formula is $K_2O, Al_2O_3, 6SiO_2$ or $K_2Al_2Si_6O_{16}$, corresponding to 65.4 per cent. of silica, 18 per cent. of alumina and 16.6 per cent, of potash. In some cases sodium replaces part of the potash. It is used in pottery mixes in place of feldspar.

447—OVERBURDEN.—Overburden is a synonym for stripping, which means the clay, dirt, stone or other material which must be removed in order to be able to dig or work the deposit required. (See Stripping; Shovel, power; Aerial tramway; Digging machinery; Ditching machine, and Excavator, drag-line.)

MANUFACTURER OF EQUIPMENT (see catalog section):
Green, L. P.

OVERGLAZE DECORATION, see Decoration, overglaze.)

OVERHEAD RAIL SYSTEM, see Conveyor, heavy duty, monorail.

OXIDATION PERIOD, see Burning, oxidation period of.

OXY-ACETYLENE, see Welding.

P

448—PACKING, SHEET.—Sheet packing is used wherever it is necessary to have a tight joint between two flat surfaces, in order to retain a liquid or gas under pressure. All pipe unions require a gasket made of sheet packing, unless made with a ground joint. The same is true where pipe is fastened to any casting, engine or other machine by a flange. Every boiler manhole must be equipped with sheet packing. These are sometimes woven to fit each manhole and plate. Sheet packing is also used in fastening some of the flanges and castings of the internal combustion engines. Some types of lubricated dies for brick machines use sheet packing to retain the oil or steam in the chest provided for that purpose. Sheet packing is made in several different thicknesses of rubber, of asbestos woven with brass wire, or of canvas. The latter is used only for special places for which it is woven to fit, like boiler man hole gaskets. Rubber sheet is used in most pipe joints, and the asbestos and wire is necessary in internal combustion engines, because the high heat and high pressure will destroy rubber. (See also Asbestos, Gasket, and Rubber goods.)

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
New York Belting & Packing Co.
U. S. Rubber Co.

449—PACKING, VALVE, PISTON, ETC.—Any flexible material which is used around a shaft or rod to prevent a liquid or gas from leaking from a chest or other container as the shaft or rod rotates or reciprocates is called "packing." In addition to preventing leaks, the packing must lubricate or facilitate the lubrication of the rod. There is usually a casting made to hold the packing, which is called the packing-box. Another casting is provided that will tighten the packing and keep it snug, which is called the packing gland. Packing is made of two principal materials; one made of strands of metal, called "metallic packing," and the other made of woven or similar material, called "fibrous packing." Packing is used on the piston rods of engines and pumps, on the valve rods of Corliss and similar engines, on valve stems, etc. As the liquids and gases in the chambers, chests, pipes or other containers vary greatly in their qualities and requirements, there is a corresponding variation in the composition and quality of the many kinds of packing. The packings for rods and stems are generally imbued with graphite in order to lubricate the rod or stem as it reciprocates or rotates. There is a special type of packing for any part of a pump, as this is made to hold water instead of steam or withstand acid.

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
New York Belting & Packing Co.
U. S. Rubber Co.

450—PAINT.—Preparations or compounds in liquid form that are intended to be placed on a wooden or metal surface that it is desired to protect from the elements or atmosphere. They consist of solids for coloring, and the liquid can be oil, water, japan, varnish, etc.

In some paints the liquid evaporates and the coloring matter is deposited as a solid on the surface, of smaller bulk than when applied. When the liquid is linseed oil or a similar substance, the mixture is called an oil paint, and the oil or liquid oxidizes, so that the resultant coating on the surface occupies more bulk or space than it did when applied. Oil paints are generally more satisfactory for outside work. Metal requires an entirely different type of paint than wood, and especially where the metal must withstand heat as in the case of stacks, boiler breeching, etc. Fire-resistant paint is made especially to withstand high heat; that is, as high as the metal will withstand. For painting the inside walls of a factory building, a spraying machine is often used as the paint can be put on the wall with much less labor and in a much shorter time than can be done with a brush. The paint is forced thru a hose, similar to the method used by a gardener spraying his plants to counteract the damage done by insects.

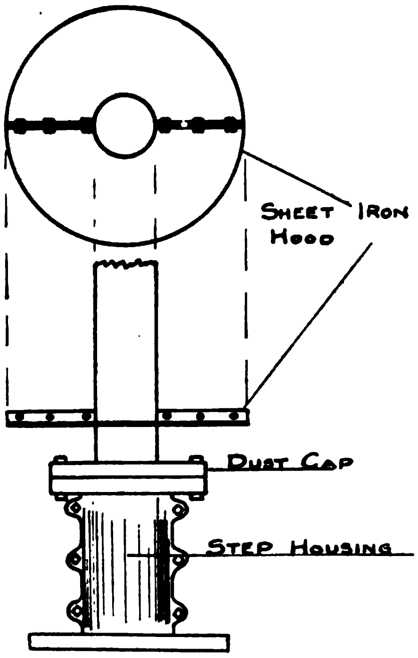
451—PALLET AND TRAY.—Pallets and trays are the pieces of equipment on which clay products are carried after being made or formed into their finished shape. They are used only when the ware would be injured if handled alone, as the expense is greater. They are used universally in the production of soft-mud brick, silica brick and shapes, china, electrical and other classes of porcelain. In a few cases they are made of boards but the very large majority are made of sheet steel in sizes and forms to suit individual requirements.

Sewer pipe and large sizes of drain tile are also placed on pallets until dry enough to be handled without damage. These pallets consist of boards put together with cleats in a more or less square form. There is usually a hole in the center of this board so that air can circulate on the inside of the ware and thus assist in drying it quicker and with more safety.

Refractory shapes, gas retorts and similar special material is also dried on pallets.

452—PAN AND PAN STEP, HOW TO CARE FOR.—The troublesome points about a pan are the scraper, screen plates, step and clutch.

The scrapers are subjected to especially hard service where hard, lumpy shales or damp, sticky clays are used. In such cases, the scrapers that came with the pan may often have to be replaced with heavier ones, or the angle may have to be readjusted to suit the particular material. The "shoes" or replaceable, adjustable plates on the front of the scrapers should just clear the screen plates (by about ¼ in.). More screen plates are broken and scrapers torn off by their being kept up too high than thru any other cause. Wedge-shaped pieces of shale get between the plates and scrapers and something must give away as the revolution of the pan drives the wedge further in. In addition to averting broken screen plates and torn-off scrapers, a "close" scraper keeps the pan bottom clean and gives maximum grinding capacity.



Step Protector.

It is important that the scrapers have a long sweep from muller to rim. Short scrapers are subjected to a far greater strain, both from friction of the bottom and blows from lumps, than a long sweeping scraper, and the former give far greater trouble.

The underscrapers, or scrapers under the pan, should have careful attention. Because their position makes examination rather difficult they are frequently neglected; yet when one of them is loosened by nuts dropping off or bolts breaking, the result is broken pan arms and screen plates or torn-up bottoms and chutes. The use of spring washers under every nut, and regular inspection will practically stop these troubles.

In some cases, however, the utmost care will not prevent the breakage of cast-iron screens; it is then wise to resort to malleable iron. These are expensive but practically unbreakable and give far better service than alloy plates which cost about the same.

How to Care for Pan Step.

The steps of dry and wet pans are practically the same. Lack of proper attention, rather than the type of step, causes most pan step troubles, which may generally be traced to dust and improper lubrication. At a small expense a dust cap can generally be fitted so that the packing can be inserted around the shaft in the same manner as in the stuffing box of a pump or engine cylinder.

Another method is illustrated, and consists of fastening a flat or umbrella-shaped circular plate tightly around the shaft, just above the dust cap. Dust falling on this plate will be thrown clear by centrifugal force.

It also often happens that, when steps are sent out of the factory, they are not provided with proper lubrication facilities. Small pipes or grease cups are generally provided, but they soon become clogged at the inside end with dust, heavy oil or metal particles. In such cases, the man who oils may think he is feeding plenty of lubricant, or that the step is not using it very fast, whereas it is getting little or nothing. A 1¼-in. or 1½-in. feed pipe, provided with a threaded cap, will overcome this difficulty. If this pipe is brought up to the factory floor level or high enough to give a "head," and the step housing is made oil-tight, the step can run on oil under slight pressure.

An extra step should always be kept on hand, and the steps in use should be examined at least once each month, preferably oftener.

Caring for Clutch.

The pan clutch requires especial consideration. Unless a pan can be stopped quickly, great damage may result from what would otherwise be a trifling accident. The superintendent himself should adjust the pan clutches and all other clutches about the plant, or delegate the job to some thoroly capable man, and forbid others to touch them. Such a rule may cause minor delays at times, but will pay well in the long run in any plant.

Miscellany.

Bushings in loose pulleys are another source of trouble when not properly lubricated. They require diligent attention, and a duplicate for each pulley should be kept constantly ready for use.

It is also good policy to have extra crown wheels and pinions on hand, since one will occasionally be broken by a sudden jar from a hard lump in the pan. (See also Bushings; Muller; Clutch and Step-plate.)

MANUFACTURERS (see catalog section):

Clearfield Machine Shops.
Eagle Iron Works.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Stevenson Co.
Toronto Foundry & Machine Co.

453—PAN, DRY.—The dry pan crusher is employed to a greater extent than any other grinding machine for shale and other hard and lumpy clays. It has a wide range of usefulness because of its ability to pulverize any hard material, from wornout fire brick, for use as grog, and hard limestone in the cement industry, to the less refractory classes of raw clays. The mechanism usually consists of two heavy end frames between which is placed the revolving pan and which are also used to carry the gears, driving mechanism and accessory parts. The pan, in turn, is equipped with heavy mullers or crushers and with tread or bed plates and steel screens in the bottom. These plates require renewal every 6 to 12 months and should be constructed of metal that will resist the great wear they are subjected to. The weight of the pans and mullers is carried largely by a vertical steel shaft which extends thru the bottom of the pan and rests on a step bearing. The design is such that when power is applied to the driving shaft this causes the main shaft and the pan to revolve and, in turn, to communicate motion to the crushing mullers. Below the pan, a movable wooden platform or other means is provided to catch the crushed material as it drops thru the screen plates. Dry pans are usually made with pan diameters of five, seven, eight, nine and ten feet, size furnished as desired. The capacity of the pan is largely controlled by the nature and condition of the material and the degree of fineness to which it must be ground. Various capacities from 10 to 20 tons per hour are obtainable. Horsepower requirement varies from 27 to 50. (See also Pan and pan step, how to care for.)

MANUFACTURERS (see catalog section):

Bonnot Co.
Clearfield Machine Shops.
Eagle Iron Works.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Robinson, Frank H.
Stevenson Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

Bonnot Co., Canton, Ohio. Dry pans of all sizes up to and including the 10-foot Bonnot dry pan which will give the largest capacity for horsepower used.

Easton Car & Construction Co., 200 Fulton St., New York, N. Y. Easton Scoop Bodies for Fords and Easton Roll-over Bodies for Fords and all other makes of cars can be furnished in ¾, 1 and 1¼ cubic yard capacities. Bulletins and prices gladly furnished upon request. See our page in the catalog section.

Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J. Mullers are independent of each other and set slightly off centre. Give proper crushing effect. Large gear reduction assures small power consumption. Runs on Timken Thrust Bearings. Machine is constructed low and rigid.

Stevenson Co., Wellsville, Ohio. Stevenson Dry Pans need no introduction to the clay industry. Being the pioneer line and ever in the lead, we feel that nothing more need be said.
THE ORIGINAL AND THE BEST —ALL SIZES.

454—PAN, WET.—For grinding and tempering in the same operation, where clay has come from the bank in a plastic condition or has come from some other grinding machine, the wet pan is extensively used. In construction the wet pan does not differ essentially from the dry pan (see Pan, dry), except that the grinding mullers are usually narrower and the floor of the pan is solid, instead of perforated as it is in the dry pan. The clay may be shoveled or spouted into the wet pan, the proper amount of water added, and the clay ground and mixed to the proper consistency. Without stopping the machine, a charge of tempered clay is usually transferred from the pan to a conveyor by the operation of a shovel mounted on a pivot close to the pan. The work of the wet pan, however, can scarcely be called continuous, as it is necessary to treat each charge separately, then remove it before more clay can be supplied. Because of this fact it has a smaller capacity than a dry pan and is rather wasteful of power; but irrespective of this slight disadvantage, the wet pan does double duty—grinds and tempers simultaneously—and its effectiveness is unquestioned. The wet pan is also used in some stoneware potteries, sewer pipe factories, and is peculiarly efficient for blending clays of different natures into a homogeneous body.

Wet pans are usually made in diameters of five, seven, nine or ten feet. The power required to operate a wet pan, as well as the capacity of the pan, is largely dependent upon the nature and condition of the material being tempered.

MANUFACTURERS (see catalog section):

Bonnot Co.
Clearfield Machine Shops.
Eagle Iron Works.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Stevenson Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J.

Mullers are independent of each other and set slightly off centre. Give proper crushing effect. Large gear reduction assures small power consumption. Runs on Timken Thrust Bearings. Machine is constructed low and rigid.

Stevenson Co., Wellsville, Ohio. Stevenson Wet Pans like our dry pans are used so extensively in the brick and sewer pipe industry for grinding and tempering, or tempering only, according to customer's needs, that they require no introduction.

OTHERS PREFER THEM. YOU SHOULD HAVE THEM—ALL SIZES.

455—PARIAN-WARE.—A grade of white, unglazed porcelain, so-called because of its resemblance to Parian marble. (See also Chinaware and several items under Porcelain.)

456—PATTERN.—A pattern is a wooden duplicate of a piece of cast iron, malleable iron or cast steel. Sometimes plaster of paris is used for patterns, especially for ornamental work. In making patterns for cast iron, a special rule is used, called a patternmaker's or shrinkage rule. 12⅛ ins. are measured on this rule, and this distance is then divided and subdivided as if it measured only 12 ins. In other words, there is a shrinkage of one-eighth inch per foot in cast iron. Patterns are usually made of white pine or similar wood which does not readily warp or shrink. Another important consideration is to obtain a wood which can be worked as easily as possible. Holes in castings are made by "cores." These are made of sand baked enough to make the binding material hold them together. Chilled cast iron is made by using a piece of iron in the proper place in the molding sand to chill or cool as quickly as possible the desired surface. Patterns must always be provided for the cores and chills. The holes in dry pan screen plates are made by chills. (See also Castings, metal and Manganese steel.)

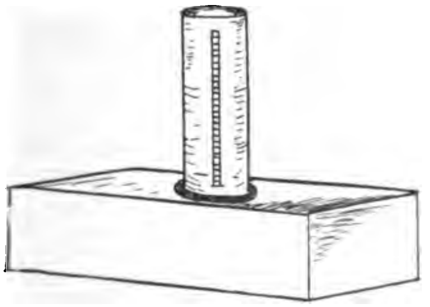
457—PERFORATED SHEET METAL.—Perforated sheet metal, in the clay industry, is chiefly used to make screens for sifting clay, cement, etc. The perforated metal screen usually has six, eight or ten holes per linear inch or the perforations may vary from 1/20 to ¼ in. in diameter. Sheet steel of No. 16 to No. 22 gage is used, depending upon the size of the perforations. The perforations may be either oblong or circular. Sheet metal screens with oblong perforations are more easily kept clean; but screens with round perforations give better grading of sizes.

Perforated sheet metal is also used for many other purposes, particularly in the manufacture of "housing" for gears, pulleys, etc., to prevent accidents to workmen.

MANUFACTURERS (see catalog section):

Link-Belt Company.
Stevenson Co.
Weller Manufacturing Co.

458—PERMEABILITY TEST.—In testing porous ware, a glass cylinder, open at both ends, is cemented in a perpendicular position on top of the piece of ware to be tested, and a measured amount of water is then poured in at the top of the cylinder. The time required for the water to permeate thru to the bottom side of the ware is noted; also, the number of cubic centimeters of water passing thru in a given time is measured.



Method of Making Permeability Test.

The permeability test and freezing test are correlative. A body which absorbs water rapidly will be less affected by freezing and thawing than another body of the same absorption which, however, absorbs the water more slowly. (See also Freezing test.)

459—PHOLERITE.—A term first applied by Guillemin in 1825 to a pearly white substance, occurring in the form of small hexagonal scales, soft and friable to the touch, adherent to the tongue, and giving a plastic mass with water. Pholerite is composed of silica (SiO_2) 39.3, alumina (Al_2O_3) 45, water (H_2O) 15.5 parts. It is likely that pholerite is present in many fire clays, perhaps even in some kaolins.

460—PIANO WIRE SCREEN.—These are made of two channel irons which form the sides and two heavy castings which form the ends of the finished screen. Piano wires are stretched from one end to the other and keys are provided that keep them as tight as possible. The wires are kept at a uniform space from one another. This space makes the mesh of the screen. In operation the material causes the wires to vibrate, thereby preventing the screen from clogging. The vibration of the wires allows them to spread a little so that the material which passes thru a piano wire screen does not always turn out the same as the same material passed thru a perforated sheet screen of the same mesh. The piano wire screen will have a little larger particles and a larger percentage of the medium sized particles. A piano wire screen will turn out more material than any other screen occupying the same space. (See also Screen, stationary.)

MANUFACTURERS (see catalog section):

Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Stevenson Co.

461—PICK.—Every clay products plant requires picks for some operation or other. Where the clay is mined by hand underground, a special type of pick called a miner's pick is used. The points are very sharp and the distance from point to point is smaller than in the ordinary or railroad pick. For outdoor work whether in the open clay pit or around track work the ordinary or railroad pick is generally used. This has one sharp point and one broad edge. The latter is serviceable for loosening stone, etc. The grub pick or hoe is very good for cutting out the roots of trees, brush, etc. Picks are T-shaped, the straight part of the T being the wooden handle and the cross part which is curved being made of metal and having the points or edges spoken of above on the ends of this curved metal part.

462—PIPE AND FITTINGS.—This item refers entirely to metal pipe. For information about vitrified clay pipe the reader is referred to Sewer pipe. Metal pipe is a cylindrical piece of cast iron, wrought iron, steel or sheet steel, used for conveying a liquid or gas, such as steam, water and compressed air. The sheet steel type is generally made by winding the sheet in a spiral form and riveting it together where it laps. It is not intended to be used for any purpose where great pressure is employed. Cast-iron pipe is generally used for underground work, because of its longer life. All underground pipe, however, should be protected from electrolysis, which is a deteriorating force produced by electricity. Cast-iron pipe is also suited for any drainage work or where there is not much pressure used. Genuine wrought iron pipe is seldom used now, the ordinary pipe with which we are familiar being made of steel lap welded; that is, the joint of the pipe or cylinder is made by lapping the two edges of the steel together, longitudinally of the pipe. The ends of wrought iron pipe are provided with threads on the outside. These fit into connections or fittings which join the pipes together or into castings, shells or other containers. Almost all fittings are made of either cast or malleable iron.

Fittings are made in a great many shapes to turn corners as elbows, to join pipes together as couplings or unions, to change from one size of pipe to another as a reducing coupling or union. This reducing feature is also made in an elbow as a reducing elbow or elbows are also made to turn a 45 deg. angle instead of 90 deg. as is the usual procedure. Bushings and reducers are also used when it is desired to change from one size of pipe to another. Tees for joining three pipes and crosses for joining four pipes are also used, and for special purposes there can almost always be found a fitting to accomplish the result desired. Piping and fittings are very satisfactory for placing guards around machinery, pits, etc., where there is danger of any man being hurt.

463—PIPE COVERING.—Pipes are covered whenever it is desired to counteract the effect produced by the radiation or absorption of heat. The main use made of pipe covering in clay products plants is the covering of steam pipe to prevent the condensation of the steam. Condensation causes a loss not only of the steam which is condensed, but in the steam which remains, unless the condensation is removed by a separator. The result of this is that wet steam is not as efficient as the same amount of dry steam. The amount of saving which can be made by covering steam pipe pays a large return on the investment. Practically all pipe coverings depend on the amount of confined air contained therein for their qualities of insulation. The lighter a material is, therefore, the more confined air it is likely to contain and the better insulations it will accomplish. Asbestos, magnesia, cork, kieselguhr, etc., are all good materials for the manufacture of pipe coverings and insulations.

MANUFACTURER (see catalog section):

Celite Products Co.

464—PIPE CUTTER, STEEL.—These attachments or tools consist of a C shaped casting which fits around the pipe. In the body of this casting three cutting rolls of very hard steel are placed at equal distances, the location of one roll being controlled thru a handle which is mounted on a screw. By means of this screw handle the depth of the cut is regulated. In operation the cutter is set so as to cut the outer surface of the pipe and as it cuts deeper and deeper the handle is screwed down. The tool cuts by reason of the revolution of the cutter around the pipe. The cutter is pulled around by hand and the hard steel wheels cut the pipe as they revolve. Pipe can also be cut on a lathe, hack saw outfit, etc., but as this always takes so much longer the pipe cutters are usually used. A pipe threading machine always has a pipe cutting attachment, so that a pipe can be cut on it also.

PIPE, STEAM, INSULATION FOR, see Pipe covering.

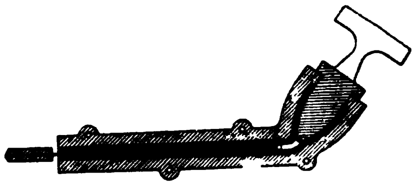
PIPE, STONEWARE, see Sewer pipe.

465—PIPE THREADER.—Threads on pipe are cut by three methods, the lathe in the machine shop, hand stock and dies, and a regular thread cutting machine. A hand stock consists of a casting which is large enough to hold the various sizes of dies for which it is fitted. Two bars extend in opposite directions from this casting and the threads are cut by the operator or operators pushing on these bars as they are revolved around the pipe. The dies are made either solid or with four sets of teeth to cut the thread of the desired pitch and diameter. In some cases the depth of the cut is adjustable. Where large pipe or a large quantity of small pipe is to be threaded, a thread cutting machine is very economical and satisfactory. The dies for cutting the threads to the desired pitch and diameter, generally made in four sections, are interchangeable and adjustable. The machine is driven by a belt or a motor and completes the cutting of the thread with little attention from the operator. It is equally efficient for cutting pipe.

406—PIPE, TOBACCO.—There are two kinds of tobacco pipes; those made in one piece and those made in two pieces, only the bowl of the latter being of terra cotta.

For the first kind, pure clays or fire clays which burn to a white color are used. This class is molded entirely by hand with the aid of a small mold (see illustration), are dried very slowly, and then burned either in small square or round up-draft kilns in saggers, or in muffle kilns.

In pipes made of two pieces, the bowl is made of a plastic ferruginous clay, similar to that used for making fine red paving tile. The bowls are shaped by throwing on wheels and finished by turning. The part for fixing the pipestem in, is then stuck on, having been turned separately. These pipes are burned in saggers.



Tobacco Pipe Mold.

On account of the dexterity required for making tobacco pipes, their manufacture is localized in places where the craft is practiced from childhood, as in England.

466A—PITOT TUBE.—A pitot tube is the bent tube or pipe that is inserted in a flue or stack for ascertaining the draft. This tube is usually placed in a vertical position with its lower end bent in the direction of the flow of the gases. This flow creates a partial vacuum in the tube which is transmitted to a manometer by means of a tube or pipe, so that the draft can be read by the variation in the level of the liquid of the manometer.

467—PLANER, MACHINE.—A planer in a machine shop is a machine for cutting or dressing flat surfaces of metal, in which the metal to be worked on reciprocates beneath a stationary tool. It is the opposite of a shaper, but is built to take care of larger work than a shaper. The reciprocating bed runs perfectly level and the work is fastened to it. The cutting tool is fastened to a yoke which spans over the bed midway of the extremes of its travel. The speed and length of the travel are adjustable. The tool cuts only as the bed goes forward, and the speed of the return motion is much faster than of the forward motion. The tool can be made to feed vertically and sideways automatically, and in some cases it is good to replace the tool by a grinding wheel driven by a motor. See Grinding wheels. The cutting tools are made of tool steel shaped to make the type of cut desired. Planers are suited for finishing any flat surface of metal, and grooves or offsets in a flat surface. (See also Shaper.)

468—PLANER, SHALE.—A shale planer is a machine which makes a vertical cut from the face of a deposit. It was originally designed for use on shale, but is equally serviceable for any clay. Many deposits vary in composition from top to bottom, and at times this variation is serious enough to threaten the success of the plant. To insure a uniform run of clay under these circumstances, the shale planer has been designed. It consists of a frame which stands as high as it is desired to make the cut. One or more chains to which cutting knives are fastened, are pulled up or down along the face of the deposit. The cutting knives cut or scrape the clay or shale. The clay or shale is loaded into cars and run to the plant. The entire machine is mounted on a track of very wide gage so that it can move along the face of the deposit. Another big advantage gained by this machine is that the clay or shale is powdered before it reaches the dry pans or other preparing machines, thus reducing the power required. The amount of power used up to the pug-mill or other mixing machinery is considerably less with a shale planer and grinding machinery than with a power shovel and similar machinery. (See also Digging Machinery.)

MANUFACTURER (see catalog section):
Eagle Iron Works.

MANUFACTURERS' ANNOUNCEMENTS:
Eagle Iron Works, Des Moines, Iowa, manufacturers of a shale planer which consists of a massive steel foundation supported on parallel rails, on which it moves forward under control of the operator, after each semicircular or partially semi-circular cut on the shale bank has been made. The swinging tower or frame and base carries the cutting chain and operating machinery, the shale being cut downward and conveyed into a receiving hopper with lifting gate in end to discharge into car or on to conveyor belt for transportation to the crushing plant. The member supporting the cutting chain being on an incline and swinging on a semicircle leaves a bank, as the result of these two motions, which is in the highest degree self supporting and exposes a minimum surface to the disintegrating effects of the elements. The advantages of the Shale Planer method of gathering clay are now fairly well understood, but will bear repeating and are as follows: (1) A complete mixture of the different strata, which insures a uniform product and uniform treatment of the material excavated. (2) The complete elimination of the powder bill for blasting and the danger to life and damage to property from the use of explosives. (3) Delivery of the material to the crusher in small particles, thereby reducing the amount of work for the crushers to the extent that the power saved will operate the Shale Planer, or omitting the necessity of installing Jaw Crushers preliminary to the delivery of the material to the Dry Pan Crushers in very hard shale. (4) Economy of operation as compared to other mechanical means of gathering clay, and a correspondingly larger saving over hand gathering methods as compared to other mechanical means.

469—PLASTER MOLD.—Used by potters in the manufacture of terra cotta and other products (see Terra Cotta, manufacture of).

470—PLASTER OF PARIS.—A hydrated sulphate of calcium, which, when dried at 110 or 120 deg. C., loses a portion of its water; at 200 deg. C. all water is lost. Plaster of paris is made by burning gypsum in a "kettle" in such a way that the fuel does not come in contact with it, otherwise the sulphite is formed. The temperature should not exceed 130 to 140 deg. C. At 200 deg. C. the plaster is said to be dead burned, and is useless for mold making, as its power of setting to a hard mass is impaired by this temperature. Plaster is made into a paste with water. It readily sets to a hard mass owing to its dehydration.

471—PLASTICITY.—Plasticity is the characteristic of clays which enables them, when mixed with water, to be molded into the innumerable shapes and sizes of modern clay wares. The cause of this valuable property in clays is not fully known. Numerous theories have been advanced by different authorities, but there is to date no definite evidence that any one of these theories is wholly correct in itself.

For exposition of water-of-hydration theory, see, among others, Vogt, Bull. d. l. Soc. d'encour. l'ind. nat., 1897, p. 633. For examples bearing against water-of-hydration theory, see among others. Ries, Md. Geol. Surv., IV, p. 248, 1902.

For information concerning texture theory, see Mechanical Analysis of Soils, Dept. of Agric., Bur. of Soils, Bull. 4, p. 15, 1896; also Wheeler, Mo. Geol. Surv., XI, p. 102, 1896; also Orton, Brick, Vol. XIV, p. 216; also Bayer and Williams, Iowa Geol. Surv., XIV, p. 86, 1904; also Linder, Tonindustrie-Zeitung, XXXVI, p. 382.

The plate theory of plasticity is discussed by Johnson and Blake, Amer. Jour. Sci. (2), p. 351, 1876; by Cook, N. J. Geol. Surv., Report on Clays, 1878, p. 287; by Haworth, Mo. Geol. Surv., Vol. XI, p. 104, 1896; by Wheeler, same volume, p. 106, 1896.

The interlocking-grain theory was probably first suggested by Olchewsky, and later augmented by two other Russian investigators, U. Aleksiejew and P. A. Cremiatschenski, but is generally disputed in this country.

For comment on ball theory, see Ries, Clays—Occurrences, Properties, Uses, p. 124, 1908 ed.; also Wolf, Tonindus.-Zeit., XXX, p. 41, 1906, and Rohland, Sprechsaal, XXXIX, p. 758, 1906.

Among others, the colloid theory has been treated by Way, Royal Agric. Soc. Jour., XI, 1850, and quoted by Cushman, Trans. Amer. Ceram. Soc., VI., p. 7, 1906; by Van Bemmelen, quoted by Cushman, Jour. Amer. Chem. Soc., XXV, No. 5, May, 1903; by Graham, Phil. Trans., p. 183, 1861; by Iowa Geol. Surv., XIV, p. 90, 1904; by Schlossing, Comp. rend., 1874, LXXIX, pp. 376-473; by Kasai, Die Wasserhaltigen Aluminum Silikate; Diss Munchen, 1896; by Rohland, Zeitschrift fur anorganische Chemie, Vol. XXXI, Pt. I, 158, 1902; by Van der Bellen, Chem. Zeit., XXXVI, 1903; by Lucas, Geol. Centrabl. f. Min., Geol. u. Pal., No. 2, p. 33, 1906; by Arons and Bischof, Dammer, Chem. Tech., I; Notizbl, IX, p. 167; by Seger, Tonindustrie-Zeitung, p. 37, 1877; by Ries, Md. Geol. Surv., Vol. IV, p. 251; by Cushman, Jour. Amer. Chem. Soc., XXX, p. 5; by Cushman, Trans Amer Ceram. Soc., VI, p. 7, 1904; by Ries, same volume, p. 44, 1904, and by Grout, W. Va. Geol. Surv., III, 1906.

The writers inclined toward the molecular-attraction theories of plasticity include Ladd, Ga. Geol. Surv., Bull. 6a, p. 29, 1898; Whitney, U. S. Dept. of Agric., Bull. No. 4; also Briggs, Bull. 10, 1897; Cushman, Bull. U. S. Dept. of Agric., p. 92, 1905; Mellor, Trans, Eng. Ceram, Soc., V, Pt. I, p. 72, 1905-6; Grout, W. Va. Geol. Surv., III, p. 54, 1906.

The conclusions of Ries (see Clays: Occurrences, Properties, Uses, p. 129, 1908) are that the examination of any extensive series of clays hardly seems to bear out the theory that any of the causes of plasticity suggested above is the sole one, but rather that plasticity is dependent on a combination of them.

The effect of bacteria on plasticity is discussed by Stover, Trans. Amer. Ceram. Soc., IV, p. 185, 1902; also see W. Va. Geol. Surv., III, p. 47, 1906.

Weathering clay also often increases its plasticity, but this may be due to several causes, such as mechanical disintegration of the mass by frost, water soaking, the oxidation of organic matter, or to the production of colloids by hydrolysis or bacterial action.

472—PLASTICITY, MEASUREMENT OF.—The test pieces shall be of the same size and shape and made in the same manner as defined in articles 1, 2 and 3 of the standard test for shrinkage. (See Shrinkage.)

The edges and corners of three test pieces shall be rubbed lightly with the finger to prevent loss in handling. They shall then be weighed on a balance to an accuracy of 0.1 gram.

After the plastic weight is obtained the test pieces shall be allowed to dry at room temperature until air dry. They shall then be dried between 64 deg. C. and 76 deg. C. for at least five hours and finally at 110 deg. C. until approximately constant in weight.

The dried test pieces shall be cooled to room temperature in a desiccator and then weighed with the same accuracy as before.

The water of plasticity shall be calculated as a percentage of the weight of the dry clay bar, by the following formula:

$$T = \frac{W_p - W_d}{W_d} \times 100$$

in which T = per cent. water of plasticity.

W_p = weight of the plastic test piece.

W_d = weight of the dry test piece.

"Shrinkage Water" is defined as that portion of the water of plasticity which is driven off up to the point where shrinkage ceases. "Pore Water" is defined as that portion of the water of plasticity which is driven off from the point where constant weight at 100 deg. C. Thus shrinkage water plus pore water equals the water of plasticity.

The data necessary for the calculations here involved are the plastic volume and the dry volume, as determined in the Method for Drying Shrinkage, and the dry weight and water of plasticity as determined in the Method for Water of Plasticity.

The following formula shall be used to determine Shrinkage Water:

$$T_1 = \frac{V_p - V_d}{W_d} \times 100$$

in which T_1 = the per cent. shrinkage water.

V_p=the plastic volume.
V_d=the dry volume.
W_d=the dry weight.

The following formula shall be used to determine Pore Water.

$$t_2 = T - T_1$$

in which t_2=the per cent. pore water.
T=the per cent. water of plasticity.

PLATE FEEDER, see Feeder and mixer, clay.

PLEISTOCENE, see Geological ages.

473—PLOW.—The plows used by clay products plants are similar to road plows, as the regular farm plow is not heavy enough. Plows are often used to loosen the overburden or surface clay. Even some shales are soft enough to be plowed instead of being blasted. A plow is usually pulled by four horses, a tractor or a cable connected to the hoisting engine. (See also Gatherer and harvester, clay, and Scraper.)

474—PLUNGER MACHINE.—A plunger machine is one in which the clay is forced thru the die to form the ware, by means of a plunger working on the principle of a cam. The feed is necessarily intermittent. There is an upright chamber in which the clay is tempered and finally forced thru openings in the bottom of the chamber into the pressing chamber. Plunger machines are usually fitted with two dies, one on each side, but at times only one is used. The two dies allow the output on one side to be cut into the desired lengths while the plunger is pressing ware out of the other die. Stiff mud is almost always used in plunger machines. Plunger machines are free from the source of great trouble with auger machines, i. e., auger laminations. For this reason they are especially suited to tender clays which show lamination. They are used for all classes of stiff-mud products, and when properly handled can make better ware than an auger machine. (See also Stiff-mud brick machinery; Die, all items.)

MANUFACTURER (see catalog section):

Hadfield-Penfield Steel Co.

PNEUMATIC CONVEYOR, see Conveyor, pneumatic.

475—POIDOMETER.—The poidometer is a machine designed to mix uniform proportions of any number of materials. Its principal application in the clay plant is to replace the pug-mill man. The poidometer is entirely automatic in operation, mixes clay and water in exact and uniform proportions, and if two clays are used, or a chemical is used with the raw material, it gives equally uniform results.

Poidometer.

In the better makes, the poidometer is self-contained and mounted on a substantial steel frame (as illustrated). The weighing mechanism is equipped with dust-proof ball-bearings. The cast-iron hopper is so arranged that the belt in passing under it pulls the material out, instead of permitting the hopper to spill the material on the belt. Two shoes, one on each side of the hopper, are set at an angle to cause the materials handled to be delivered onto the belt in the form of a ribbon. A regulating gate on the hopper has double knuckle joints and is connected to the walking beam by means of pivot-joints and knife-edges. The hopper gate moves on rollers enclosed in a special housing, and is polished on the inside to prevent any material which touches the gate from causing friction. The roller under the center of the belt (which primarily functions by supporting the loaded belt and thus causing a compensative mechanical reaction against the scale beam) is ball-bearing mounted.

The method of weighing is simple. The distance between the center of the tail pulley and the center of the last supporting roller under the hopper actually provides a continuous scale platform. Consequently, when material is delivered to the belt the weight of this continuous platform compensates by means of the supporting roller, and the transmission of this impulse to the scale beam with its weights and counterweights thus causes the gate to fluctuate as much as is necessary to give a predetermined weight per foot of running belt per minute.

The general method of operation is continuous, but batch operation may be obtained by simply attaching a special mechanical weighmaster.

By means of a liquid measure attachment, liquids can be delivered in conjunction with solids. This is done by passing the liquid thru the liquid measure synchronously with the passing of the dry materials over the belt. The admixture is then delivered to the pug-mill, thus eliminating the pug-mill man and also insuring a more even temper of the clay.

Self-starting and automatic-stop arrangements are provided, as is also a productometer which records the amount of material the poidometer has handled for any given unit of time. In addition to the labor saved the uniformity of quality and quantity of production is a big item in favor of the use of a machine of this kind.

MANUFACTURER (see catalog section):

Schaffer Engineering & Equipment Co.

MANUFACTURERS' ANNOUNCEMENTS:

Schaffer Engineering & Equipment Co., 2828 Smallman St., Pittsburgh, Pa. An automatic pugger. Eliminates the man with the hose. Feeds clay and water to the pugmill and produces a perfectly tempered column.

POP VALVE, see Safety valve.

476 — PORCELAIN. — Pottery made from about the same materials used in whiteware, except great care is exercised in their selection, the proportions being so graded as to produce a vitrified and translucent body, and the ware is burned to a higher temperature than is ordinary china. Porcelain fluxed by feldspar is called spar china, while that fluxed by calcined bones is called bone china. (See also Chinaware; Bone China and Electrical Porcelain.)

MANUFACTURER (see catalog section):

Engelhard, Chas., Inc.

PORCELAIN, ELECTRICAL, see Electrical porcelain.

478—PORCELAIN FOR MECHANICAL PURPOSES.—The hardness of porcelain and its resistance to cracking permit it, in some cases, to be used for mechanical purposes, particularly for grinding, as porcelain mortars, for lining ball mills, etc. This grade of porcelain is made the same as is porcelain for electrical purposes (see Electrical Porcelain). After being molded the stiffened body is repressed in hydraulic presses. The burned ware is turned to shape by means of emery or black diamond, the only materials available whose hardness exceeds that of porcelain.

479—PORCELAIN, HARD.—This ware has a silicious body made of china clay and alkaline or partly calcareous fluxes. It is usually covered with a glaze, the vitrification of which takes place at the same time as the burning of the body, at a temperature of 1,300 to 1,400 deg. C. (2,372 to 2,552 deg. F.). The glaze cannot be scratched with steel. (See also Chinaware, Electrical porcelain, Porcelain for mechanical purposes, Parian-ware, Architectural porcelain, etc.)

MANUFACTURER (see catalog section):

Engelhard, Chas., Inc.

PORCELAIN, HARD, DECORATION OF, see all entries under Decoration.

PORCELAIN, ITS RELATION TO WHITEWARE, see Whiteware, its relation to porcelain.

480—PORCELAIN, SOFT, DULL.—The various kinds of soft porcelain may be hard-fired without any glaze, just as hard porcelains are. Thus far, only French porcelain (see Porcelain, soft vitreous, "French," "fritted," or "Reaumur") has been used for this purpose, and this gives dull ware of beautiful appearance. Dull, phosphated porcelain is less satisfactory, and has been replaced by a special body, which, when burned, has a slightly yellowish color, with a dull brilliancy, resembling the beautiful marble from Paros, whence came its name "Parian" (see Parian-ware).

481—PORCELAIN, SOFT, DULL FELDSPATHIC.—Small objects, buttons and imitations of pearl and agate are made from this material, which was invented about 1840 by Prosser, who used the English porcelain body, then simply a mixture of feldspar and bone ash, to which plasticity was given by the addition of a greasy body, which was destroyed when burned.

The body is formed of feldspar, which is powdered and treated with sulphuric acid to separate part of the impurities (iron oxide). To the purified feldspar is then added some coloring oxides, or sometimes a little bone ash or chalk. Milk or an emulsion of casein in a solution of boracic acid is next added so as to give the material a consistency firm enough for it to be molded in a press. Five hundred buttons are molded at one stroke. They are arranged automatically on a sheet of paper, which is used to carry them onto a fireproof plate. This is first heated, so that the paper is burnt up; then the plate is put into a muffle where it remains for about 10 minutes. It is then drawn out, the buttons on it are taken off with one stroke of a rake and it is covered with a fresh sheet of paper. The muffles are arranged to the number of 30 in a rectangular downdraft kiln. The burned buttons fall into a series of boxes fastened to a pivot, where they finish cooling, and from which they are taken out thru a movable bottom. They may be decorated, if required, by chromo-lithography with vitrifiable colors, or gilded. Cameos and small cubes (mosaics) have also been manufactured by this process.

481A—PORCELAIN, SOFT, SEGER'S.—Seger completely imitated the Japanese porcelains from a chemical point of view, but in physical properties Seger's porcelain is less translucent, less hard, more fragile and of a slightly yellowish tint. According to Bourry (see Searle's trans. ed., A Treatise on Ceramic Industries, 1911, pp. 452-3), the following are the different compositions of body at which Seger stopped:

Plastic clay.......	31.0	15.5	15.5
Zettlitz kaolin........	....	....	13.0
Sennewitz kaolin......	....	19.0	....
Feldspar	30.0	30.0	30.0
Powdered Hohenbacka sand	39.0	35.5	41.5

The plastic clay contains 81% pure clay, 19% sand; the Zettlitz kaolin, 97% pure clay, 3% sand; and the Sennewitz kaolin, 65% pure clay, 35% sand.

The chemical composition is approximately: Silica, 77 to 77.5%; alumina, 17 to 17.5%; lime, 0.30%; magnesia, 0.20%; potash, 3.75 to 3.80%; soda, 0.65 to 0.70%. This can be represented by the formula $0.38RO, R_2O_3, 7.7SiO_2$, and is almost identical, as to rational analysis, with the composition of Japanese porcelain.

The body of Seger porcelain should be plastic enough to lend itself readily to molding; like hard porcelain, it is heated to convert it into biscuit, then glazed and burned at a temperature sufficient to bend Seger Cone 9. This comparatively low temperature for burning (the same as the new Sevres porcelain) and its slight hardness, places this ware among the soft porcelains.

The glaze corresponds to the formula—

$$\left.\begin{matrix}0.7CaO\\0.3K_2O\end{matrix}\right\} 0.5Al_2O_3,\ 4SiO_2,$$

and is very similar to that of the Japanese glazes. The physical composition of the glaze may vary as follows:

Sand, 27.3 to 21.0%; Zettlitz kaolin, 13 to 0.0%; Sennewitz kaolin, 0.0 to 19.2%; feldspar, 42.1%; marble, 17.7%.

482—PORCELAIN, SOFT VITREOUS, "FRENCH" "FRITTED," OR "REAUMUR."—This material, whose manufacture has not been successfully revived, was first made in France, and abandoned shortly after the discovery of hard porcelain. It is not really a ceramic product, but a glass (heated to a temperature which is not sufficient to melt it, but enough to give it a milky transparency, and covered with another soft glass), tho its use, appearance and the processes of its manufacture caused it to be classed among pottery.

483—PORCELAIN, SOFT VITREOUS, OR NEW SEVRES.—So-called after the city in France in which it was discovered. In 1844, after numerous attempts to produce a porcelain that would lend itself better to decoration than hard porcelain does, and particularly one that would give a turquoise blue from copper, this ware was discovered. According to Lauth and Dutailly, the body is composed of:

1. Frit, the composition of which is sand 77 parts, soda 8.5 parts, saltpeter 16.5 parts, and chalk 18.4 parts.
2. The composite body is then made up of Fontainebleau sand 49.02 parts, frit 27.45 parts, chalk 16.66 parts, and plastic clay from Dreux 6.86 parts.

This body differs from "fritted" or "French" porcelain only in a larger ratio of lime to alkalies, and a slightly greater amount of alumina and silica as compared with the fluxes. The body is also slightly more plastic, but still very weak and presents some difficulties in molding. The first burning (at Seger Cone 9) is intended to vitrify the body, and not, as in hard porcelain, to convert it into biscuit. The saggering is the same as for burning glazed, hard porcelain. The glaze is composed of sand 25.52 or 35.15 parts, chalk 8.60 or 7.43 parts, Cornish stone 65.98 or 7.43 parts, and feldspar .0 or 57.42 parts. The glaze is applied by dusting or by dipping. The decoration may be underglaze, stained glaze, and also overglaze. The temperature of the glost firing is low enough to allow the production of blue from copper and of reds from iron.

484—POROSITY.—The porosity of a clay is defined as the ratio between the volume of the clay and the open or pore space among the clay particles. It is thus a ratio of volumes and is expressed in percentage of the total volume occupied by the clay. On the porosity of clays depends largely the amount of water to make them plastic. Unless completely vitrified, all clays are more or less porous.

Porosity of any body composed of an aggregate of particles depends on the size and shape of the particles. If the particles are all spherical or of the same size (as in a mass of shot), porosity is at its maximum. But clay is made up of multitudes of small mineral particles of multifarious sizes and shapes, and, even when clay is in its most compacted condition, it is impossible for all of these particles to be in contact with each other at all points. For this reason, the smaller particles fill in the spaces between the larger grains. It is this variation in the sizes and shapes of clay particles that makes the drying of plastic clays such a variable problem.

Porosity is also a very important physical factor in burned clay wares.

The apparent porosity is determined by the following formula:

$$P = \frac{Sf - Wf}{Vf} \times 100$$

in which P = the per cent. apparent porosity
Sf = weight of saturated fired test pieces in grams
Wf = weight of the fired test piece in grams
Vf = volume of the fired test piece in c. c.

In this formula distilled water is the liquid used. The same formula can be used for determining the porosity of unburned clay if the specific gravity of the kerosene is taken into account.

PORTABLE ELECTRIC DRILL, see Drill, electric portable.

PORTABLE PYROMETER, see Pyrometer, portable.

PORTABLE RAILWAY TRACK, see Frogs, rails and switches.

PORTABLE SHAFT KEYSEATER, see Keyseater, portable, shaft.

485—POTTER'S LATHE.—Is used for very precise work in "turning" and decorating certain objects (for description, see Turning).

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Mueller Machine Co., Inc.

486—POTTER'S MOLD FOR FORMING WARE.—Molds are essential in all methods of forming ware, except throwing. Clay, alabaster, steel, gun metal, and brass have been used for making molds. Clay molds, dried and hardened in the sun, have not proved durable, the surface being readily affected by moisture from the clay. The difficulty with the others mentioned was that they were non-absorbent and did not lend themselves to the ready reproduction of the clay pieces, because they were slow in drying. Metal molds, however, are largely used in producing fine impressions of raised figures in stoneware and jasper.

Plaster of Paris is the material best adapted for molds, chiefly because it readily takes and rigidly retains the exact shape in which it is formed and when dried it is highly absorbent and capable of absorbing water from the clay. It thus allows the ware to stiffen more readily and to be taken from the mold sooner, and consequently facilitates reproduction. (See also Plaster of Paris.)

Mold Making.

In the production of molds, a model is first prepared in clay by the modeler, the size of the model being determined by the nature of the body or clay in which the article is to be produced. The model is then centered on a perfectly true revolving disc and surrounded by what is known as a cockle, which is made of stiff clay, zinc, linoleum, or leather. Plaster is then poured over the model, and when it is set the outside shape is turned true and to a definite size and shape, this being identical to the inside shape and size of the jigger head in which the molds are to be fixed. The mold rests on a set-off on the top of the head and the lower part of the mold that fits in the head acts as a notch. Care must be taken to keep the article perfectly centered during this operation, or when the cup or saucer is being made; otherwise irregular thicknesses result. The first mold is called the block mold.

The outside of this block is well sized, the size usually being a strong solution of soft soap in boiling water with sometimes tallow candles introduced. This greasy mixture when applied to the surface of the plaster mold renders the plaster non-absorbent and gives a smoothness to its surface, so that when plaster is poured over it the second layer can be readily separated from the first. The clay model is then taken from the block, and the inside of the block mold is thoroly washed and well sized at the top. The diameter at the top is extended by applying clay to the outside of the mold, which has already been perfectly centered. A cockle is then placed around the outer edge of the clay, and plaster is poured into the mold and allowed to flow over the extended top until it reaches about 1½ ins. in depth.

When the plaster is well set it is turned perfectly true at the top and sides and afterwards withdrawn from the block mold on the upper side. The second casing is called the case mold. The extended flange of this is turned down, forming a kind of notch, close to the outer edge of the block mold.

After the outside of the block mold and the extended flange have been sized a cockle is placed on the outer edge of the flange and the space is filled in with plaster, which is poured in until the height of the block mold is reached. The outside of this is turned roughly true after the plaster has set. This is called the outer case. The outer case gives the corresponding shape of the outside of the block mold, and when the block mold is removed the cavity, after the whole piece has been sized, can be again filled with plaster and a replica of the original block mold obtained, which replica is called the working mold. The block mold is usually preserved, so that if a case mold breaks or wears away the case mold can be renewed.

487—POTTER'S WHEEL.—A manually operated device resembling a potter's jolly or jig, and used for the same purpose. (See also Jiggering and jollying.)

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Mueller Machine Co., Inc.

488—POTTERY, CLASSIFICATION OF.—Earthenware includes all classes of opaque and nonvitreous pottery, from the crudest product to wares closely allied to china. China and porcelain include ware of dense, vitreous, and translucent body. They are classified as follows:

A. Natural body.

Under this division comes (1) common earthenware or crockery, covered with lead glazes or soft tin enamels; and (2) stoneware, which may be salt-glazed or lead-glazed—the latter including such products as yellow ware, Rockingham ware, jet ware, and samian ware.

B. Compounded body.

This class embraces (1) ware of porous, nonvitreous body, such as cream-colored (or C. C.) ware, and whiteware; and (2) ware of dense vitreous, and translucent body, such as (a) feldspar porcelain, produced by high biscuit and low glost fire; (b) feldspar porcelain produced by low biscuit and high glost fire; and (c) bone china, produced by high biscuit and low glost fire.

Also see the following specific classes: Earthenware; Crockery ware; Stoneware; Yellow ware or rockingham ware; Jet ware; Samian ware; C. C. ware; Queen's ware, ironstone china, and white granite ware; White earthenware; Majolica and faience; Belleek; Parian-ware; Chinaware and Porcelain.

POTTERY COLORING MATERIALS, see Decorative coloring materials.

489—POTTERY DECORATION.—See the following specific items: Printing; Decalcomania, chromo, or litho transfer work; Ground laying; Ground laying, wet-process; Decoration, airbrush; Lining; Gilding; Incrustation, pottery; Hand painting; Stamping; Sponging; and Staining.

490—POTTERY FOR WATER AND FILTERS.—Pottery is made in all southern countries for cooling liquids. On account of its porosity, the liquid oozes out on to the surface, and if carefully put in a current of air, a quick evaporation takes place, which lowers the temperature from about 41 to 43 deg. F. (5 to 6 deg. C.). Such pottery is also used in filters. The body is the same as for ordinary ware, but special methods are used to render it more porous. If the clay used is sufficiently plastic, sand or, better, grog or burned clay may be added. Sometimes salt is added. In the low temperature at which this pottery is burned the salt remains undecomposed, and is afterwards dissolved out by putting the pottery in water.

The same porous body can be employed as a filter for clarifying liquid, particularly water. For this purpose, white, china clay bodies, similar to porcelain, have been used. Their manufacture presents no special difficulties, being about the same as that used in making terra cotta lumber, except the combustible materials added must be reduced to a powder, or the air holes produced would permit the water to run out, rather than ooze out, of the ware.

POTTERY, HISTORY OF, see Ceramics, history of.

POTTERY MANGLE, see Mangle, dipper's.

POTTERY, MANUFACTURE OF.—For details of preparation of clay for pottery ware see Clays, preparing and weathering; Grinding; Washing trough; Blunger; Filter press; and Ball Mill. For steps in tempering see Chaser mill; Pug-mill; Hand-wedging; and Wedging table. For molding processes see Throwing; Jiggering and jollying; Pressing; and Casting. Also see Dryer, pottery; Kiln, biscuit and glost; Dipping; and Pottery decoration.

491—POTTERY, MATERIALS USED IN MANUFACTURE.—The following clays and chemicals are used in the manufacture of pottery; Ball clay, barium carbonate, baryta, bauxite, feldspar, cornwall stone, fire clay, flint, silica, sand, fluorspar, kaolin, china clay, lime, magnesite, manganese oxides, plaster of Paris, slip clays, soda ash, Sagger clays, talc, whiting. In addition thereto glaze and enamel supplies and body materials of various types are also required. (See each entry. The various clays are described in the subdivisions under Clay.)

492—POTTERY, METHODS OF FORMING.—The prepared clay may be formed into articles of ware by any one of the following methods (each of which is described under its specific name): (1) Throwing; (2) Turning; (3) Hollow ware pressing; (4) Potter's molds (hand molding) for forming ware; (5) Flat ware pressing; (6) Jollying; (7) Jiggering; (8) Casting; (9) Compression, etc.

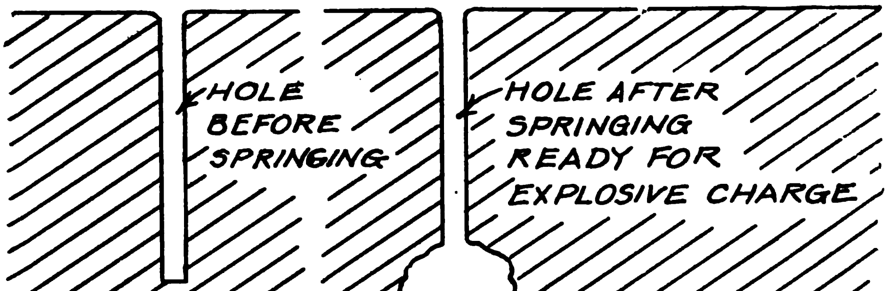
In this country earthenware articles are not made by throwing, while chinaware articles are partly formed by throwing, both in England and in this country. Cups and other articles after being made by machinery are frequently finished by turning here. In England many china and earthenware articles are formed by throwing and completed by turning.

492A — POTTERY MOLDING MACHINE, SEMI-AUTOMATIC.—It has taken years of careful study by expert mechanical engineers to produce a Semi-Automatic Pottery Molding Machine that would meet the requirements of potteries manufacturing many types of plain ware. These machines passed thru the experimental stage fourteen years ago, and are today being used with most satisfactory results in the manufacture of flower pots, crucibles, insulators, corroding pots, stoneware, carboy stoppers, sleeves, nozzles, runner brick, saggars, and numerous other articles in plain pottery.

The operation of these machines is entirely different from the old type press, which simply pounded the clay into the mold, a method that was both slow and very unsatisfactory, and it will also make better ware at a rate nearly ten times as fast as the jigger or potter's wheel. The clay is spun and spread in the mold under heavy pressure with the result that it is evenly distributed, and when ejected, the ware is smooth, true and uniform thruout.

MANUFACTURER (see catalog section):
Baird Machine & Mfg. Co.

493—POWDER, BLASTING.—An explosive used very frequently in blasting operations in a clay pit, or mine. It does not have the disruptive force of an equal amount of dynamite, as it burns more slowly, but is to be preferred for some uses. It is a solid and is made in various sizes of grains. Its chemical composition varies somewhat, but saltpeter, charcoal and sulphur are some of its principal ingredients. Its explosive or disruptive force is dependent on the fact that it contains sufficient oxygen to unite with the other ingredients when ignited, to form gases that occupy 1,000 or 1,500 times as much space as the powder before ignition. Blasting powder may be ignited by an electric cap or by a regular fuse and detonating cap. At times a small charge of dynamite is placed in a hole in order to spring it. No tamping is used and the theory is that by creating a pocket, the explosive that is used when the hole is finally shot, whether dynamite, powder or a mixture of the two is used, will be more concentrated and therefore a smaller charge will be required. On the other hand it is possible that fissures will be opened up around the hole that will tend to destroy the full effect of the explosive. The advisability of this practice, therefore, should be fully investigated in every instance. In mining or digging clay or shale the use of explosives is necessary unless the material is very soft or a power shovel or other digging machinery is used that is heavy enough to handle the material as it lays. Even in those cases the use of explosives often assists to such an extent that its use shows good economy.



Method of Creating a Pocket for Blasting by Powder.

POWER SHOVEL, see Shovel, power.

494—POWER TRANSMISSION EQUIPMENT.—The many appliances, attachments, and pieces of equipment used to transmit power are classed under this item. A complete index can be found in the Departmental Index.

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Gandy Belting Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Philadelphia Drying Machinery Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.
Weller Manufacturing Co.

PRE-DEVONIAN, see Geological ages.

495—PREHEATING CLAY.—Preheating, where it is practical, serves as a preliminary step to drying, the object being to make the plastic clay mass more porous and permit the moisture it contains to escape at the surface, thus insuring uniform, safe drying.

The process of preheating is based upon the colloid theory, now generally accepted by clay technicists, which assumes that clay contains a great number of cells or sacs which absorb water thru their walls, swell and close up the interstitial pore spaces. This stops any flow of water to the surface of the ware being dried and consequently results in cracking of the surface to relieve the strain. The air gets into these cracks and continues the drying process which at the same time enlarges the cracks.

The object of preheating is to introduce the clay to a temperature that bursts the sacs and sets free the included water, driving it off, and at the same time destroying the structure of the sac, so that it can not take up water and hold it except by surface tension, nor can the colloids swell up and close the pores of the clay.

The value of preheating depends upon whether the work can be done within the specific temperature ranges required to make the preheating safe and uniform thruout the clay mass. Clays differ greatly in the degree of preheating required, the variation ranging approximately from 440 deg. F. to 810 deg. F.

PRESS, FILTER, see Filter press.

496—PRESSING.—In the pottery industry, this term applies to the molding of ewers and vessels of oval or elliptical section by means of sectional molds, consisting of two or three pieces, the inner surface of the mold conforming to the outer surface and design of the object to be molded. A slab of clay is placed in each section, being carefully pressed in, the mold is then put together, and all seams are smoothed out with a wet sponge. After drying for a few hours, the sections of the mold are removed. Clocks, lamps, water pitchers, and similar articles are molded in this manner.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.

PRESS, SEWER PIPE, see Steam press.

PRESS, STEAM, see Steam press.

PRESSURE GAGE, see Gage, pressure.

PRESSURE REGULATOR, see Regulator, pressure.

497—PRINTING, POTTERY.—A process almost identical with the copperplate process of bank-note printing. The design is cut on copper or steel plate. The color (it must be a metallic color) is mixed with the proper medium and is then worked into the engraved plate. The surplus is cleared off by means of a printer's knife and boss. The printing is done on an especially prepared paper, and this paper, while the print is still moist and gummy, is transferred to the ware to be decorated and well rubbed on. The printer has assistants, the first being the cutter, who, after she receives the paper, cuts it into pieces according to the design. It is then handed to the transferer, who places it in its proper position on the article to be decorated. The ware is then passed to the rubber, who, by means of a piece of flannel and a little soft soap, rubs the transfer tightly against the ware. The ware is allowed to stand for a short time, when it is placed in a bath of water and the paper floats off, leaving the imprint upon the surface of the ware. This process is sometimes done upon biscuit ware before glazing and the product is known as underglaze printed ware, in which case it must go thru a hardening-on kiln to burn out the fatty oils from the print; in other cases it is done upon the glaze, and, like other decorations, must be again put thru the decorating kiln to be burned into the glaze. (See also Oil, printer's.)

498—PRODUCER GAS.—Producer gas is made from the ordinary grades of coals in a gas producer (see Gas producer); it has a heat value of 140 to 160 B. t. u.'s per cu. ft., which is about one-sixth of that of natural gas. It is used for practically all kinds of fuel purposes as well as for power. In the burning of lime or clay, it can yield a uniform quality of product, avoiding the irregularities of overburning in one portion while underburning in another portion of the kiln. The chief chemical constituents of producer gas are nitrogen, carbon monoxide and hydrogen; a very small percentage of oxygen and carbon dioxide is generated when anthracite or coke is used, and when bituminous coal is used, a sprinkling of methane and illuminants is also found.

MANUFACTURER OF PRODUCERS (see catalog section):
International Clay Machinery Co.

PRODUCER, GAS, see Gas producer.

499—PUG-MILL.—Consists of a hollow metal cylinder, placed either horizontally or vertically, with a shaft running thru its center, from end to end, equipped with blades or "knives" arranged like the thread of a screw. The action is such that the revolving blades cut, masticate and wedge the clay into a perfectly homogeneous mass, and deliver it, thru the worm pushout, similar to a worm conveyor, in a uniform condition, in most cases free from laminations.

Pug-mills form a necessary part of the clayworking equipment, both in clay products plants and earthenware potteries. In the pottery industry the various types of pug-mills have rated capacities of 3,000 to 6,000 lbs. per hour; in brick plants, etc., the various types have capacities ranging from 3,500 to 15,000 brick per hour, and in some cases more.

Until recently, pug-mills were built entirely too light for the heavy duty required of them, and, where an old type is still in operation, troubles are often constantly arising from this source. Generally, the trouble is to be found in the gears and intermediate shaft. Gear trouble can be remedied only by replacing the cast-iron types with cast- or cut-steel gears. When the intermediate shaft often breaks, a shaft of larger diameter, or if that is impossible, one of special steel, should be substituted. In any case, an extra shaft should always be on hand with keyways cut and ready for an emergency. Most pug-mills are set on a platform and thus subjected to considerable vibration; this tends to loosen bolts and destroy bearings. The use of spring washers under the nuts will reduce the bolt trouble, but the pug-mill should be examined daily to prevent accidents.

MANUFACTURERS (see catalog section):

Baird Machine & Mfg. Co.
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Steele, J. C. & Sons.
Stevenson Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

Freese & Co., E. M., Galion, Ohio. Adjustable pug knife sockets—a socket constructed to receive a round shanked pug knife, allowing the knife to be set at any desired angle.

Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J. Exceptional machine for pugging clays for saggars and other purposes. Double mixing shafts assure thoro kneading of the material before it enters the pugging worm.

International Clay Machinery Company, Dayton, Ohio. New line of single geared pug mills; ring oil bearings including ring oil marine thrust. Round steel shaft with inserted cleaver type knives easily adjustable. See our pages in catalog section.

500—PULLEY.—A pulley is a wheel which fits concentrically on a shaft and has a wide surface on its perimeter or outside circumference. A tight pulley is one that is fastened to the shaft by a key, set screw or other attachment, and a loose pulley is one that revolves loosely around the shaft.

A clutch pulley is a loose pulley that becomes fastened to the clutch, when the clutch is thrown in, and drives the machine by that form of contact.

A belt operates on the perimeter or surface of a pulley and each pulley can be either a drive pulley or driven pulley, depending upon the function of the shaft upon which it is placed. This perimeter is "crowned," that is, the diameter at the center of the pulley is slightly larger than at either edge. This is done in order to make the belt travel true and not run off one side or other of the pulley. Pulleys are usually made of iron or wood. Those of iron are made of all cast iron, or all sheet steel, or a combination of the two, under which circumstance the hub and spokes are of cast iron and the perimeter or wide surface on the circumference of sheet steel. Some are made of all wood and there are also some made with iron hub and spokes and wooden perimeter. A split-pulley is one that can be taken apart so that it can be put on at any place on a shaft without disturbing any of the other pulleys or bearings.

MANUFACTURERS (see catalog section):

Caldwell Co., W. E.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

501—PULLEY, SPECIAL, SLOTTED.—In conveying or elevating any plastic material by means of a belt, there is always some of the material that gets on the inside of the belt. Being plastic, this material packs on the pulley if an ordinary pulley is used. This results in practically making a new crown on the pulley and the belt as a consequence tends to travel to one side. Guide pulleys cannot keep it in line and the edges wear off in a short time. To overcome this trouble slotted pulleys are used. These are usually made with cast-iron hub and spokes. In place of a solid rim as in an ordinary pulley, each spoke has a plate fastened to it which fits crosswise of the pulley. The length of this plate is the same as the width of a solid rim would be, and the width of the plate is about an inch or two. As these plates on the spokes are several inches apart, any plastic material which gets on the inside of the belt passes between them and does not cause any trouble (see also Conveyor, belt; Elevator). There are other types of special pulleys made to decrease the amount of slippage between the belt and the pulley. These consist of inserts of cork or soft composition placed in the perimeter of the pulley to increase the grip that the belt has on the pulley.

MANUFACTURERS (see catalog section):

Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:

Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of the Williams Patented Never Slip Pulley.

PULSOMETER.—A trade name for one make of pump described under the heading Pump, steam, without piston or plunger.

502—PULVERIZER.—Any machine that is used to break up the clay into smaller particles can be called a pulverizer. The different types are described under specific headings. See therefore, Pan, all items; Crusher, all items; Disintegrator and Pulverizer, roll-hammer and swing-hammer.

MANUFACTURERS (see catalog section):

Bonnot Co.
Gruendler Patent Crusher & Pulverizer Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:

Bonnot Co., Canton, Ohio. The Bonnot pulverizer—complete grinding and air separation in one mill, discharging a finished product of any necessary fineness.

503—PULVERIZER, ROLL HAMMER AND SWING HAMMER.—These machines operate on the principle of reducing the material (which is fed to them in lumps of 3-in. sizes or less) by striking it while in suspension, as opposed to the attrition mills which mash or roll the substances between two more or less hard surfaces.

The roll hammer pulverizer has a heavy cast-iron or steel supporting base which houses a revolving shaft. Six hammers (resembling so many iron rolling pins, both in their design and grinding action) are suspended from steel arms which, in turn, are attached to cast-steel discs that are keyed to the shaft. Ordinarily, the shaft makes 1,000 to 1,200 r. p. m. The bottom of the crusher is equipped with sectional steel screen plates, curved to suit the movement of the hammers. The clearance between the screen bars may be as small as 1/16 in. The distance between the hammers and the screen plates should be equal to the clearance between the screen bars, in order to obtain maximum capacity and avoid wasting power.

The pulverizing action is twofold. The material enters at the top of the machine and is struck a tremendous blow by the revolving hammers, and that material which is not instantly pulverized is projected against chilled impact or breaker plates located at the top and back of the machine. The partially reduced material then falls down and passes over the cage of screen bars, where it is further ground between the hammers and the bars until it is sufficiently fine to pass thru the screen.

The arrangement of shafting and bearings generally permits the machine to be driven from any available source of power.

The swing hammer operates and is constructed on practically the same principle, except the rolls are eliminated and replaced by a series of swinging hammers, say 30 in number, revolving with the movement of the shaft.

The capacity of roll hammer and swing hammer pulverizers depends, first, upon the size of the machine, and, second, upon the degree of fineness to which the material is to be pulverized. Generally, in handling limestone, shale, etc., with ⅛ in. clearance between the screen bars, the output of the various sized machines will range from one ton to 50 tons per hour, and require from 15 to 100 h. p. to operate.

MANUFACTURERS (see catalog section):

American Pulverizer Co.
Gruendler Patent Crusher & Pulverizer Co.
Hadfield-Penfield Steel Co.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:

Gruendler Patent Crusher & Pulverizer Co., 928 North Main St., St. Louis. Manufacturers of Pulverizering and Crushing Machinery, Elevators and Conveying Machinery, Revolving and Shaker Screens. The Steam Jacket attachment, which is one of the latest improvements, prevents choke up of wet material—wet shale and clay can be taken direct from bank without any danger of clogging the machine. This is true in all kinds of weather. All parts coming in contact with the clay or shale are steam heated, which prevents sticking of wet material. Prices and quotations sent on request. See our page in catalog section.

Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Inventors of the Hinged Hammer and Swing Hammer Pulverizer and largest exclusive manufacturers in the world of this equipment.

504—PUMP.—A pump is a machine by which water or other liquid or gas is elevated or conveyed under pressure thru pipe, hose or other medium. Every plant that has a boiler must have a boiler feed pump, which forces water into the boiler. The power is usually exerted thru a piston which is really a small steam engine. Instead of a crank as in a steam engine the piston rod has another piston on the other end which reciprocates in a water cylinder. Valves are provided for opening and closing at the proper time to admit and eject water. These valves are usually of hard rubber or composition, and are made of two qualities, one for cold water and one for hot water. When using a heater for the feed water, the pump takes the water from the heater to pump it into the boiler. The power for a boiler-feed pump can be exerted by a motor or any other means that is convenient. A mine or pit pump is often of the same type and even some deep well pumps are built along similar lines, but they are made either to draw the water from a considerably lower level or to discharge it at a higher level. Where large quantities of water are to be handled from a pit, it is well to use one of the forms made for that service. (See also Pulsometer and Ejector.) Force feed oiling systems use pumps to force the oil into the bearings. These pumps are in the form of a plunger, in some makes. (See also Injector; Regulator, pressure, and other items under Pump.)

505—PUMP, CENTRIFUGAL.—The centrifugal pump is designed for a large delivery of water at a low or moderate lift. It consists of a wheel with curved blades which revolves rapidly in a metal casing, the water being drawn in at the center and discharged at the circumference, similar to the action of a fan in displacing air. Centrifugal pumps are not adapted for use with long suction pipes, but the pump will function when partly immersed in the water. A foot-valve may be used, but not with the same degree of efficiency as when the water can flow direct to the pump. The pump is made either in a horizontal or vertical pattern, the horizontal type being apparently the easier to clean. As neither type will function unless filled with water, it is usually advisable to have a small supply tank placed a short distance above the pump to facilitate starting. The centrifugal pump may be coupled direct to the engine, direct connected to a motor, or belt-driven, as conditions warrant. Care should be taken to secure a pump that can be easily opened and cleaned and the wearing parts economically renewed.

PUMP, FILTER PRESS, see Filter press pump.

506—PUMP, HYDROSTATIC FOR BOILER TEST WORK.—All boilers are rated to withstand a certain working pressure. The high heat necessary to obtain this pressure causes an expansion in the metal of the boiler which, being exerted at the seams, rivets and joints, tends to assist the ability of the boiler to withstand this pressure. To counteract any beneficial effect caused by the heat, a cold water or hydrostatic pressure is resorted to and the allowable pressure shown by this test is usually the one used by insurance companies. In some plants one boiler can be disconnected from the others and cold water can be pumped into it. The best practice, however, is to use a special pump called a hydrostatic test pump. This is usually worked by hand and is equipped with the necessary check valves, by-passes, etc. With this equipment the entire boiler, including the steam dome, can be filled with water up to the pressure desired, and every seam, rivet and joint thoroly inspected.

507—PUMP, OIL.—In the storage of oil transfer pumps are often used to transfer the oil from the container in which it was delivered and put it into the container in which it is to be stored. These consist only of a tube of sheet iron and a piston containing a valve. The piston raises the oil and a trough is provided for allowing it to run into the storage tank.

In force feed oiling systems the pumps consist of rods working back and forth in pipe or other rods that are slightly larger on the inside than the first named rods are on the outside. These pumps are really plunger pumps, in that way. Valves are provided that admit and discharge the oil at the proper time.

508—PUMP, ROTARY.—These are really small centrifugal pumps for draining small places or forcing a small stream of water. The reader is therefore referred to Pump, centrifugal.

509—PUMP, SLIP.—These pumps are used to pump the slip or mixture of clay and water as it comes from the blungers and settling tanks into the filter press. It is usually a vertical pump of the plunger type as this kind of pump will handle the silt and clay in the water better than a piston type of pump.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.

510—PUMP, STEAM, WITHOUT PISTON OR PLUNGER.—These pumps are adapted to all operations requiring ease of installation, simplicity of operation, a minimum amount of repairs and care, and the ability to handle semi-fluid materials, gritty water, stone, etc., in capacities ranging from approximately 900 to 80,000 gals. per hour. In design, they consist fundamentally of two bottle-shaped chambers, with their necks communicating at the top (which is the point of steam intake), the chambers being placed side by side and equipped with the necessary intake, suction, check and discharge valves. In operation, the vacuum created by the condensation of steam causes the water to fill the chamber, and this action, in the alternate chambers, is so rapid and regular that the stream of water leaving the discharge pipe is practically continuous. They have a highly individual and valuable sphere of usefulness in the clay products industries, especially in pit and mine work.

511—PUMP, VACUUM.—A vacuum pump is a device for emptying heating coils of condensed water, when operating under low pressure or exhaust steam. A vacuum pump will pump the water back to the boiler room to be sent thru the heater, boiler-feed pump or any other arrangement. All water of condensation, however, must be removed as fast as formed and that is the duty of a vacuum pump. In clay products plants the largest use of vacuum pumps is in connection with the many types of dryers using steam as the heating medium. A vacuum pump will not feed directly to the boilers.

PUMP VALVE, RUBBER, see Valve, pump, rubber.

512—PYRITE.—A mineral, chemically known as FeS_2=Fe 46.6 %, S 53.4%, and is referred to by clay miners in some districts as sulphur. Not uncommon in some clays and when present can be seen with the naked eye. It is yellow in color and may occur in big lumps, small grains, cubes, or even in flat rosette-like forms. Exposed to weather, pyrite changes readily, first to sulphate of iron, then to limonite. Because of this easy conversion to limonite, pyrite is rarely permanently present in clays. Clays containing pyrite are not usually desirable, and in mining the pyritic material should be rejected. Pyrite is often present in fire clays and causes the black spots on the face of fire brick. On account of its shiny yellow appearance and resemblance to gold it is often called "fool's gold."

513—PYROMETER, OPTICAL.—In optical pyrometers the intensity of the light emitted by an incandescent body whose temperature is sought is measured by comparing the intensity of the light which the body emits with that emitted by some standard source, such as a gasoline lamp or an incandescent lamp under specified conditions. Optical pyrometers are therefore essentially, in principle, photometers adapted to meet the varying requirements of shop and laboratory use.

In these pyrometers light of a single color is generally used to get rid of the difficulties in photometry incident to color differences, and also for the reason that the laws connecting the temperature of a body and the intensity of the light emitted are simpler if we deal with a single wave length (color) only.

The chief use of optical pyrometers is in the measurement of extremely high temperatures, and where it is impractical to use the electric pyrometer.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Thwing Instrument Co.
Wilson-Maeulen Co.

514—PYROMETER, PORTABLE.—Practically any of the ordinary types of pyrometers are made portable, but in addition there are some that are made especially for portable use, and are self-contained; that is, the part that is in contact with the heat or the radiation and the dial to indicate the heat, are made in one piece of equipment without any wires or other connection being exposed. One type of this class of pyrometer is the expansion pyrometer and another the platinum pyrometer. In each case the instrument is enclosed in a pipe about two or three inches in diameter closed at one end and having a dial on the other for indicating the temperature. These pyrometers are very serviceable around a small plant, as the temperature can easily be found by placing the closed end of the pipe thru the wall of the kiln or boiler setting. The benefits are limited, however, as a portable pyrometer of this type cannot be made recording.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Thwing Instrument Co.
Wilson-Maeulen Co.

515—PYROMETER, RADIATION.—As the name indicates this pyrometer is made to indicate the temperature of any material by radiation. It will not show the temperature of a gas, however, but that is not a drawback in the ceramic industry. Likewise it will not indicate temperature of a kiln or boiler that is filled with smoke. Most pyrometers of this type will indicate the temperature of an object irrespective of the distance between the object and the pyrometer, provided, however, that the radiating surface be large enough to prevent the radiation of any other object entering the instrument. For this purpose, it is evident that the greater the distance the larger must be the surface of the radiating body. These pyrometers are usually made on the electric thermocouple principle. They are very useful for determining the temperature of a boiler or kiln fire, and are usually portable.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Thwing Instrument Co.
Wilson-Maeulen Co.

PYROMETER, RECORDING, see Pyrometer, thermoelectric.

516—PYROMETER, THERMOELECTRIC.—These instruments indicate or register the heat in a kiln, boiler or other place thru the variation in the electromotive force in two different metals when heat is applied. The operation is based upon the principle that the ends of rods or wires of two unlike metals welded together create, when heated, an electromotive force which, if the wires are brought into contact at another point, will produce a small electric current with intensity corresponding to the difference in temperature at the two points of contact. Copper, iron, nickel and platinum and the alloys of the last two metals are the materials that are used to make most of the thermocouples (which is the term used to designate the two metals which are subjected to the heat). These metals are enclosed in a porcelain tube and that tube is enclosed in a fire clay tube in order to protect the delicate metals from the reducing effects of the heat. In the ordinary installation around a clay products plant the thermocouple is placed thru the crown of the kiln or near the fire box of the boiler. The wires connecting these two metals are led to a galvanometer, which is scaled to show degrees of heat instead of variations in current. This type is called the indicating pyrometer.

The recording pyrometers are the same except that the variations in the heat move a pen across a paper which is arranged to show the heat variations for 24 hours or more. Some recording instruments will record the continuous operation of as many as six kilns or other furnaces at the same time.

Pyrometers are the source of many economies in the clay products field. The burning can be watched so that no time or fuel is wasted. The men themselves will watch them and the lessons taught by the needle or pen as it varies up or down are often as potent and productive of good results as the instructions of the foreman or superintendent. One of the big advantages of the installation of a recording pyrometer is the ability to know exactly what the night fireman did, and the fact that he knows that the instrument will make a written report of his work. One of the main advantages gained in the use of pyrometers is the ability of adopting a standard burning schedule, and seeing that the heat is raised on every kiln according to this schedule. This insures burning the kiln with the utmost speed, least fuel and the smallest possible loss. The same procedure enables a larger output to be produced with the same investment in kilns.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Thwing Instrument Co.
Wilson-Maeulen Co.

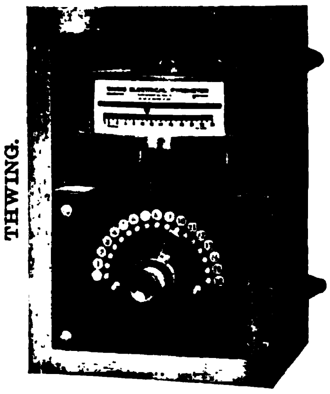
MANUFACTURERS' ANNOUNCEMENTS:

Brown Instrument Co., 4503 Wayne Ave., Philadelphia, Pa. Brown Pyrometers afford an accurate means of measuring and recording the degree of heat required to burn or to melt a given clay. One of the outstanding advantages of the Brown Pyrometer lies in the fact that it has extremely high resistance, and because of this high resistance its readings are entirely unaffected by normal changes in length of wiring or atmospheric changes in temperature along the wiring connecting the thermocouple and instrument. The instrument is of a simple, husky construction with few working parts, which insures greater accuracy in measuring and recording temperatures, greater dependability, and longer life for the instrument. As soon as a Brown Pyrometer is installed our service man calls to adjust and test it, and you are assured of as nearly perfect an installation as is possible. Our men are permanently located in New York, Pittsburgh, Cleveland, Detroit, Chicago, St. Louis, Denver, Los Angeles, San Francisco and Montreal. Other instruments made by The Brown Instrument Company that have the saving habit are Brown Indicating and Recording Thermometers, Brown Indicating and Recording Tachometers, Brown Mercurial Thermometers, Brown Recording Pressure Gauges, Brown Time and Operation Recorders, Brown Draft Gauges and Brown Resistance Thermometers.

Engelhard, Chas., Inc., 30 Church St., New York, N. Y. The widely varying reports obtained from various plants equipped with pyrometers and pertaining to the benefits derived therefrom are entirely traceable to two factors: 1. A failure on the part of the plant which has them to make intelligent use of them. Pyrometers are only tools to be placed in the hands of a man who knows how to use them. A study of the records will show where a few hours here and there can be clipped from the firing period. It will show where water-smoking can be carried a little faster without danger of checking. It will show when the carbonizing temperature is reached and will make it possible for the burner to hold this temperature until carbonization is completed, without danger of going into the vitrification range too soon. In other words, he can proceed with assurance and save fuel by eliminating the ups and downs, which without pyrometers he cannot do and can complete his burn in a shorter length of time than would otherwise be possible.
2. On account of the lower first cost base metal couples are too often used where platinum 10% rhodium thermocouples are required. Frequently, in order to make the base metal couples stand up without too rapid failure, they are not inserted beyond the inside of the crown. Of course this gives very erroneous data. If good equipment is installed and if intelligent use is made of it, pyrometers are one of the best investments that a brick plant can make.

Wilson-Maeulen Co., 383 Concord Ave., New York, are the manufacturers of the Tapalog Multi-Record, Multi-Color Pyrometer Recorder. This instrument has been used for years in the steel industry and is recognized as the standard in that field where the necessity of uniform and constant supervision of the heat is more important than in the clay products industry. Our pyrometers are equipped to show continuous records of the heat in six kilns at the same time. They do this on one transparent sheet of paper and each kiln has a separate and distinct color. By an arrangement of switches the six hottest kilns can be connected to the recording paper, and in this way one instrument can take care of any number of kilns. Indicating instruments are provided that show at any time the heat of any of the kilns not connected to the recording instrument.

Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia.



Thwing—see catalog section.
Wall Types Indicating Pyrometer with Dial Switch.

517—PYROMETER, WEDGEWOOD.—An instrument which depends for its recording action upon the shrinkage of clay cylinders, whose contraction is presumed to be proportionate to the temperature to which they are exposed. Their behavior is not suited to close measurement.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Thwing Instrument Co.
Wilson-Maeulen Co.

PYROMETRIC CONE, see Cone, pyrometric.

Q

QUARRYING, see Clay winning.

518—QUARTZ.—This mineral (formula, SiO_2) is found in nearly every clay, the amount varying from about 1% in kaolins or fire clays to over 50 or 60% in some very sandy brick clays, but the grains are seldom large enough to be seen with the naked eye. The grains are translucent or transparent, usually of angular form in residual clays and rounded in sedimentary clays. They may be colorless, but more often are colored superficially red or yellow by iron oxide. Nodular masses of amorphous silica, generally known as chert or flint, are found in some clays, particularly in many residual clays of the southeastern states. Quartz pebbles are also found in many clays of the Mesozoic or Pleistocene period; in fact, a large portion of the sand grains found in coarse, gritty, surface clays of sedimentary nature are quartz. Both quartz and flint are highly refractory, being fusible at Seger Cone 35 (3,326 deg. F.), but the presence of other minerals may exert a fluxing action and cause the quartz to soften at a much lower temperature. In pottery quartz is used as a part of both glazes and bodies.

518A—QUARTZITE.—Quartzite is a quartz bearing mineral rock. Quartz is pure silica, and quartzite has impurities mixed in it.

519—QUEEN'S WARE, IRONSTONE CHINA, AND WHITE GRANITE WARE.—These terms are used indiscriminately by potters to indicate a grade of white earthenware for dining-room services one grade higher than C. C. ware. They are made of superior quality materials, the body being slightly stained by a solution of cobalt, which gives it a bluish-white cast.

R

RADIATION PYROMETER, see Pyrometer, radiation.

RAILS, see Frogs, rails and switches.

RAILWAY ENGINE, see several entries under Locomotive.

520—RARE ELEMENT.—A term applying to such rare elements as cerium, yttrium, berryllium, molybdenum, platinum, rhodium, whose presence in certain clays has been determined by exhaustive analyses. Some of them are used for pyrometers.

521—RATTLER.—The rattler consists of a ruggedly constructed, heavy iron cylinder having concave ends, mounted on suitable iron or steel framework and operated by a gear drive. The machine is used to test paving block. During the test, a 300-lb. charge of cast-iron spheres is placed in the cylinder with ten dried paving brick. The rattler is then revolved 1,800 times in 30 minutes. A good paving brick should not lose more than 20% of its weight. Less than 20% loss indicates a good brick. The brick should be hard burned, capable of not more than 1% to 3% of absorption, when tested. (See also Brick, paving.)

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.

RECIPROCATING FEEDER, see Feeder and mixer, clay.

522—RECORDER, TIME AND OPERATION.—Recorders of this type are made to record the time necessary to perform any job or the quantity of production. The exact time of the arrival of any mail or report can be stamped thereon by one of these appliances. In making time studies of machine output a counter or recorder is very valuable as it shows the production possible when the machine is operated to full capacity at all times. Of all time or operation recorders the "time clock" is used most in clay products plants, as it forms the basis for all pay roll work when figured on the hourly or day rate, and at the same time forms a check on the report of the foremen as to whether or not each man was at work.

MANUFACTURER (see catalog section):
Brown Instrument Co.

RECORDING PRESSURE GAGE, see Gage, pressure recording.

RECORDING PYROMETER, see Pyrometer, thermoelectric.

RECORDING THERMOMETER, see Thermometer.

523—RECTORITE.—Related to kaolinite. Monoclinic. Appears in leaves or plates resembling mountain-leather; hardness less than that of talc; feels soapy; luster pearly; color, pure white, sometimes stained red with iron oxide. Composition: $HAlSiO_4$ or Al_2O_3, $2SiO_2$, H_2O=silica 50.0, alumina, 42.5, water 7.5.

524—REFRACTORIES.—A refractory material is any substance used in a furnace constantly under such conditions as to be subjected to high temperatures, that will successfully withstand the temperatures encountered, and that will resist abrasion and corrosion at the places where used. It must possess the following properties: (1) It must be comparatively infusible; i. e., have an appreciably higher melting point than that obtained in the place where it is used. In ore-roasting furnaces, temperatures run up to 1,000-1,100 deg. C. In electrical furnaces, they may reach 3,500 deg. C. (2) It must resist abrasion, as is met with in iron blast furnaces, etc. The refractory may be softened at high temperatures. Magnesia melts at 1,900 deg. C., but softens at 1,500 deg. C. (3) It must resist chemical corrosion. Acid brick cannot be used in places where basic substances or fluxes are used. (4) It must have the property to withstand sudden changes in temperature. In some furnaces requiring sudden changes in temperatures, magnesia is subject to spoiling off; so is silica brick; but chromite brick will not. (5) It must possess low heat conductivity. which, fortunately, is a property of most refractories. Furnaces are often built of a number of refractory materials: e. g., magnesia, which is highly refractory but a high conductor, is backed up by silica brick.

Chemically, refractories are divided into three classes:—

1. Siliceous refractories: (a) Fire clay, aluminous fire clay or siliceous fire clay; (b) silica brick; (c) ganister.

2. Basic refractories: (a) Magnesite or magnesia; (b) dolomite lime; (c) bauxite.

3. Neutral refractories: (a) Chromite; (b) graphite; (c) carborundum and siloxicon.

Of these the first sub-class (which is the most common); namely, fire clay, is divided into two divisions according to the ability to withstand destructive influences:—

1. Fire clays which resist high temperatures and high load conditions. These must embody: (1) Minimum softening temperature at Cone 32; (2) no excessive deformation at 1,350 deg. C. (2,462 deg. F.) and 50 lbs. pressure per sq. in.; (3) not over 0.18 equivalent of RO nor over 3 equivalents of silica.

2. Fire clays which resist high temperatures but not high loads. These embody: (1) Minimum softening temperature at Cone 32; (2) no excessive deformation at 1,350 deg. C. (2,462 deg. F.) and 25 lbs. per sq. in.; (3) not over 0.2 equivalent of RO nor 3 equivalents of silica. (See also Bauxite, Chrome, Fire Brick, Silica Brick, Zirconia, Siloxicon, Dolomite and magnesite, and Carborundum.)

525—REGULATOR, PRESSURE.—These attachments are used wherever the amount of water or steam delivered to a certain pipe or other point should be kept below a definite pressure. Two general types are in use, one for steam and the other for water. The steam regulators are used chiefly in connection with a drying system that uses steam. The pipe line carrying the steam has a regulator to keep the pressure in the dryer at a certain amount. Dryers are built to use live steam at lower pressure than that used on the boiler, and a pressure regulator is the best way to accomplish this with success. Water pressure regulators are used principally on a pump that discharges into a pipe having a valve at a distant point that may be closed without the knowledge of the operator of the pump. This is especially serviceable on the line running from the boiler room to the pit. With this arrangement the men in the pit can open and close the valve on a water line without any danger, and they can be sure of having water for the machines at all times.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.

526—REGULATOR, TEMPERATURE.—There are two departments in clay products manufacture where temperatures exert a marked effect on the quality and cost; namely, drying and burning. In order to increase the efficiency, temperatures are regulated or controlled as closely as possible. In drying, recording thermometers and wet and dry bulb thermometers are found to be very useful. The latter equipment enables the operator to regulate the air and heat so as to attain the maximum output with the highest quality. In burning, pyrometric cones and pyrometers, of both the recording and non-recording types, are made to control and regulate the temperature to attain a like maximum output with the highest quality and lowest cost. Recording thermometers and recording pyrometers are equipped with a sheet or roll of paper on which the record of the heat for 24 hours or longer is placed. (See also Thermometer, Pyrometer, and Cones.)

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.

527—REPRESS.—A repress is a machine into which a brick is put in order to reshape it, and usually brand it. It is ordinarily used in connection with soft-mud or stiff-mud brick. In making soft-mud brick a hand powered repress is used. The brick are allowed to dry partially on the floor, after being molded either by hand or by a soft-mud machine, then picked up and repressed. In making stiff-mud brick the column of clay issuing from the machine is cut into brick by wires. These brick are a little thicker and not quite as large as the finished brick are desired. These wire-cut brick are then put thru a power repress, branded and repressed to the desired size. Represses are used chiefly for paving and fire brick.

The repress machine consists primarily of a mold into which the brick are placed and then subjected to heavy pressure. In late models, the pressure is applied gradually and regularly by a plunger from above or by plungers both from above and below. The brick are delivered to the repress on a table or moving belt from which they are automatically charged into the molds. Accuracy in design is essential, in order that the brick may be placed squarely in the molds with each revolution of the plungers; the brick must likewise fit and fill the molds as perfectly as possible. Each size of brick requires a separate mold.

In some represses the mold is stationary, and the pressing is done by plungers working from top or bottom, or from both moving towards each other. In other types, one plunger is stationary, while the other moves against this, carrying the mold with it. Pressure is exerted by means of a cam, crank or toggle joint. Movement is imparted to these by levers, if hand-operated, or by clutch pulleys and heavy gearing, if power-driven. In very substantially built represses, pressures up to 45,000 lbs. per sq. in. can be exerted on the brick, with suitable means provided to regulate the pressure as desired. The power required to operate a two-mold repress varies from one to two horsepower; the capacity varies from 1,000 to 4,000 standard size brick per hour.

MANUFACTURERS (see catalog section):
Bonnot Co.
Clearfield Machine Shops.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.

MANUFACTURERS' ANNOUNCEMENTS:
Bonnot Co., Canton, Ohio. The Bonnot repress has a continuous movement absolutely free from jolt or jar.

REVOLVING SCREEN, see Screen, revolving.

528—RING-PIT.—The ring-pit is used in common brick yards and serves the same purpose as a pug-mill, except it has less capacity and takes up more room. It consists of a pit, 20 to 25 ft. wide and about 3 ft. deep, lined with heavy boards or brick. Revolving in this pit is a heavy, 6-ft. iron wheel, which is so geared that it travels around the pit in a spiral path, thus thoroly masticating the clay mass. Ordinarily, from five to six hours are required to temper the clay in a pit that holds from 25,000 to 30,000 brick. Ring-pits may be operated by either steam power or horse power but are not used in modern plants.

MANUFACTURER OF EQUIPMENT (see catalog section):
International Clay Machinery Co.

529—ROCKINGHAM WARE.—A specific class of goods made largely in teapots. The body is composed of a cheap buff or red clay, while the glazing material is of a rich brown, this coloring being produced by the oxide of manganese. In recent years, Rockingham ware has been made in a great variety of forms, many of which are elaborately decorated.

530—ROLLER BEARING.—Roller bearings refer to the system of lubrication in which the shaft or axle is surrounded by rollers of hard steel. These rollers make a snug fit between the axle or shaft and the hub or main casting of the bearing. When the axle or shaft turns, the rollers roll, thus converting sliding friction into rolling friction. This requires much less power than when the shaft or axle revolves in the plain babbitted bearing. The rollers and the space between the axle or shaft and the hub or main casting are generally packed and filled with graphite or a similar lubricant. The diameter of the rollers in each bearing must be uniform. Roller bearings are suitable for heavy duty work. Almost all cars, whether in the pit or in the factory, are equipped with them. Several cases are known where they have been installed and operated successfully on the heavy duty wet pans of a plant manufacturing silica brick. Roller bearings have been lately installed in ordinary line shaft boxes and bearings in place of babbitt metal with very good results. (See also Ball Bearing.)

MANUFACTURERS (see catalog section):
Easton Car & Construction Co.
International Clay Machinery Co.
Weller Manufacturing Co.

531—ROLLER, GUIDE.—Guide rollers are used to keep a belt conveyor in place. The natural tendency of a belt conveyor is to get out of line at times, and for this reason guide rollers are placed at frequent intervals. They consist of a frame holding an upright pin, which is stationary. On this pin is mounted a roller which is also upright and which revolves on the pin. A grease cup is provided which lubricates between the roller and the pin. The roller does not revolve except when the belt starts to run off of its course. In that case the roller stops it and on account of the fact that the roller revolves there is no wear on the edge of the belt as there would be if a board or other solid device were used. It is well known that the edge of a belt must not be allowed to wear, because if the wear extends in far enough to permit the plies to separate, the life of the belt will be very short. For this reason guide rollers are a necessity. Many elevators and drive belts could be equipped with guide rollers to good advantage for the same reasons given above. (See also Conveyor, belt, Elevator.)

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

ROOFING TILE, see Tile, roofing.

ROOFING TILE MACHINERY, see Tile machinery, roofing.

ROPE DRIVE, see Drive, rope.

532—ROPE, MANILA.—Manila rope is made by intertwining fibers of manila. The fibers are woven into strands and these strands are woven into the finished rope. This is the common rope found at any place that a rope can be of service. One of the special places for the use of this rope is in operating rope drives. (See Drive, rope.) Manila rope is also used in a "block and falls" for hoisting, and some types of this kind of installation can be locked with the load in suspense, as is done automatically by chain blocks.

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

533—ROPE, WIRE.—Wire rope is made by twisting together a number of wires into a single strand, and then twisting the strands around a hemp center or core. The hemp center provides little additional strength, but acts as a cushion to preserve the shape of the rope. In some cases the conditions under which the rope is to be worked require a wire center. While the wire center adds to the strength of the rope, it is not advisable except when absolutely necessary. The strength of wire rope depends primarily upon the material of which the wires composing the rope are made. The material used in the manufacture of wire rope may be grouped into five main divisions: (1) Iron, (2) crucible cast steel, (3) extra strong crucible cast steel, (4) plow steel, (5) special or improved plow steel.

Iron rope is a very soft and low tensile strength material and is half again stiffer than steel rope. It is used only to a very limited extent. Crucible cast steel is a lower quality of high-grade steel rope, and is tough and pliable. Extra strong crucible cast-steel rope is of moderately high tensile strength and quite flexible. It is used for ordinary work and can be used on small sheaves and drums. Plow steel is a very high quality rope which combines lightness and great strength. It is used for heavy work where conditions permit the use of sufficiently large drums and sheaves. It stands abrasion better than cast-steel ropes. Improved plow steel rope is the highest quality obtainable, and is very useful where great strength, lightness and abrasive resistance are required.

Almost every set of conditions and uses requires a certain type of wire rope, and general recommendations are impossible. Tensile strength, flexibility and resistance to abrasion are three important factors in wire rope, and each of them must be considered in the purchase of this material. In general, there is less care in the purchase of this material and more opportunity to make mistakes in securing the wrong type of rope for a given use than any other equipment on the plant.

The proper lubrication of wire rope is most important, but its importance is often overlooked. Wire rope should be coated with grease when not in service, as otherwise the rope will rust very rapidly.

(See also Aerial tramway; Conveyor, cable; Crane; Excavators, drag-line; Drive, rope; Drum, winding, and Wire rope compounds.)

MANUFACTURER (see catalog section):
Weller Manufacturing Co.

ROTARY DRYER, see Dryer, rotary.

RUBBER BELT, see Belting, rubber and composition, and Conveyor, belt.

534—RUBBER GOODS.—Rubber is a very serviceable material around any plant, and is made into several forms. It is made into several different thicknesses of sheet, which are suited to use as gaskets or packing on any flat surface, such as flanges in piping, pump heads, valves, etc. Rubber is one of the necessary components of hose, both water and steam. It is also used some in packing for valve stems where steam, acids or other corrosive materials are not present. Steam has a very destructive effect on rubber, unless it is the type called "hard rubber." Hard rubber is used for pump valves, for the renewable seats of globe valves, etc. In certain classes of belt conveyors the belts are rubber surfaced. One of the largest uses now for rubber is the tires for auto trucks, industrial trailers, etc. (See also Hose, rubber; Hose, steam; Packing, sheet; Hand leathers; Footwear; Conveyor, belt.)

MANUFACTURERS (see catalog section):
Goodyear Tire & Rubber Co.
New York Belting & Packing Co.
U. S. Rubber Co.

RUBBER HOSE, see several entries under Hose.

RUBBER PUMP VALVE, see Valve, pump, rubber.

535—RUBBER TUBING.—This is a flexible pipe, tube or hose formed entirely of rubber. It is not made to withstand steam or pressure (for this purpose, see Hose, all entries), but is very well suited for connecting up draft gages, flue gas analysis instruments, etc.

MANUFACTURERS (see catalog section):
New York Belting & Packing Co.
U. S. Rubber Co.

RUNNER BRICK MACHINERY, see Sleeve, nozzle and runner brick machinery.

536—RUTILE.—A mineral titanium oxide (TiO_2=Ti 60%, O 40%) presumed to be of widespread occurrence in clays, since titanium is usually found in the chemical analysis. Rutile occurs chiefly in the form of bristle-like crystals. No exhaustive or systematic efforts have been made to determine its effect on the behavior of clay, altho the effect of the titanium it contains on the fusibility of clay merits some attention, at least in the higher grades.

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537.—SAFES.—Receptacles for the keeping of valuables, papers, money, etc. They are usually constructed of steel and made fireproof. To a certain extent they are burglar proof, some more so than others. Some safes are quite heavy but are nevertheless portable. All safes are equipped with a combination lock on the door. A safe is found in almost every office and if a vault is not used should be large enough to hold all valuable papers, so that in case of fire these valuable papers will be recovered. (See also Vaults, safety.)

538—SAFETY DEVICES, MECHANICAL.—These refer to the protection that must be provided around all machinery to prevent injury to employees. All belts must be covered when they are in places accessible to employees because the lacings, rough places on edge of the belt, etc., may catch the clothing. All shaft collars should be provided with countersunk set screws. Force feed oiling systems, as described in a special item, afford immunity from the danger of oiling machinery while it is in motion. All gears should be provided with guards so that no one could accidentally get his clothing or fingers caught therein. Dry and wet pans and other crushing and grinding machinery should have guards provided to prevent anyone falling in accidentally. Pulleys should also have guards. In the machine shop and woodworking shop all saws, boring machines, planers, etc., should be equipped with automatic guards which are always in place when the machine is not in use and which move sufficiently to allow the machine to be used and at the same time protect the operator while in operation. Guards around belting, machines, etc., should be made of pipe, about one inch in diameter, and fastened to the floor by special plates made for that purpose.

539—SAFETY VALVE.—This is also called a pop valve and its duty is to open and allow an excess of pressure to escape from a boiler. Every boiler has an allowable working pressure, and if the pressure increases much beyond this, danger and trouble may be encountered. Safety or pop valves are adjustable within certain limits, and can be set so that they will open when the pressure increases beyond the safe allowable working pressure. Their use is especially necessary where the load varies and a sudden reduction in the amount of steam used raises the pressure. The steam gage sometimes does not register properly and the actual pressure may be higher than shown. A safety valve proves beneficial in this case. There is usually a disc which is held against a seat by a spring or by a weight placed on the end of a lever. On the other face of this disc the boiler pressure is exerted, so that when the pressure increases beyond the ability of the spring, or weight to withstand it, the valve opens. It closes after the excess steam has been allowed to escape and the pressure reduced to the safe allowable pressure which is the same as that which the spring is able to withstand. (See also Valve, all items.)

540—SAGGER.—In the burning of wares such as wall tiles, enameled brick and most grades of pottery which cannot be burned in contact with the fire gases, the effect of a muffle is sometimes secured by enclosing the ware in saggers. Saggers are simply small vessels of resistant fire clay in which the ware is tightly sealed or "luted" with moist clay. They are stacked in the kiln just as pieces of ware would be, in such positions that the kiln atmosphere may circulate freely among them, thus allowing the ware within them to be burned largely by radiation and conduction.

The average composition of saggers from 22 factories is: Tight burning plastic clay, 10%; open burning plastic clay, 20%; tight burning sandy clay, 17%; open burning sandy clay, 7%; grog, 46%.

For sagger-making equipment see Pan, dry; Pan, wet; Pug-Mill, Elevator; Screen, several items; Clay, preparing and weathering; Cutter, all items; Washing trough; Dryer, sagger and Wad-squeezing.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Baird Machine & Mfg. Co.
Mueller Machine Co., Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Mueller Machine Co., Inc., 21-23-25 Ward Ave., Trenton, N. J. Press No. 1 for tile and electrical porcelain factories, and potteries. Press No. 2 for large saggers such as are used in manufacture of sanitary ware.

541—SALT GLAZED SEWER PIPE, SURFACE PIMPLING OF.—Surface pimples on the pipe are caused by the incipient fusing, bubbling and swelling of small particles of shale, lying close to the surface of the pipe; these particles, it can be assumed, would not act similarly to large particles of shale burned under similar conditions. The size and frequency of the pimples depend upon the fineness of the grinding; consequently, homogeneity is the solution to the problem. The pimples appear between 2,000 and 2,060 deg. F. They are known to appear in greatest size and extent on the pipe in fast burning kilns, where the temperature lowers considerably after the start of the salting. A ratio of high grate area to kiln area is responsible for the short duration of full fire period on fast burning kilns, and is consequently an indication of the kind of pipe that will come from the kilns.

542—SALT GLAZING.—Salt glazing is the only glaze employed in the sewer pipe industry. It represents the simplest and crudest method of applying glaze to any ware. Common salt is shoveled into the fire boxes when the temperature has reached the maximum used in the burn. The intense heat in the presence of the kiln gases and water vapor (the salt is commonly moistened before being applied) dissociates the sodium chloride (NaCl) and the following combination with water takes place: $2\ NaCl + H_2O = 2HCl + Na_2O$. The resulting free hydrochloric acid is expelled and the soda attacks the alumina, silica and iron of the clay forming the glaze.

543—SAMIAN WARE.—Consists of teapots, sugar bowls, cream pitchers, etc., composed of a red or brown clay body, and glazed with a transparent glaze showing the natural color of the clay body. These goods are generally carefully potted, the ornamentation being largely of embossed work upon the clay.

544—SAND.—This earthy substance, composed of quartz and silicates, is an important antishrinkage agent, which greatly diminishes the air-shrinkage, plasticity, and tensile strength of clay, its effect in this respect increasing with the coarseness of the material; thus, clays containing a high percentage of very finely divided sand (silt) may absorb considerable water in mixing, but show a low air-shrinkage. The brick maker adds sand or loam to his clay for the purposes mentioned above, and the potter brings about similar results in his mixture by the use of ground flint.

Of the different minerals included under sand, the glauconite is the most easily fusible, followed by hornblende and garnet, mica (if very fine grained), feldspar, and quartz. (See also Quartz and Silica.)

SAND DRYER, see Dryer, sand.

SANDER, MOLD, see Soft-mud brick machine.

545—SAND-LIME BRICK.—Sand-lime brick are made out of clean sand and hydrated lime. They are mixed dry in a tube mill or wet in a wet pan in a proportion of 3-4 per cent. of lime to 96-97 per cent. sand. The mixture is then fed into the press, which may be built almost the same as a dry press for clay brick, or into a rotary press which consists of a horizontally revolving table containing any number of molds. As the table revolves the molds pass the charging hopper, then the pressing mechanism, and finally the ejecting levers. The brick are then put onto cars and run into a large steel cylinder, which is steam tight. The brick are here subjected to a steam pressure of about 120 pounds per square inch for about ten hours, and when withdrawn are ready for the market. Sand-lime brick are very suitable for building purposes, especially where the cost of clay brick is too high. The cylinders for hardening sand-lime brick are usually over 60 ft. long, and 6 ft. wide.

MANUFACTURERS OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Stevenson Co.

546—SANITARY PRESSING.—Refers to the hand process of modeling bathtubs, sinks, laundry tubs, etc. These articles are built by hand in very large molds and require exceptional care and skill in making.

547—SANITARY WARE.—Under this head comes pottery goods used for sanitary and various domestic purposes. The body is usually a porcelain body, altho earthenware bodies have been used. The body composition usually ranges as follows: ball clay, 10 to 20 parts; kaolin, 20 to 40 parts; flint, 20 to 40 parts; feldspar, 15 to 30 parts. One or two per cent. of a mixture of magnesium carbonate or calcium carbonate or talc is frequently added to produce color, toughness and translucency. The clay substance in sanitary ware is always above 40 per cent. and is usually around 50 per cent. This is necessary to give a longer vitrification range and more viscosity.

Sanitary ware is prepared as is most other pottery materials, and is usually cast in pottery molds. Sometimes it is pressed by hand, and one or two plants have been known to use the dry press process. The ware is usually fired at a high temperature, around Cone 10, and is usually vitreous. After the ware is biscuited a glaze is applied, usually white and opaque, and the ware burned in glost kilns.

Both in the biscuit and glost burns the ware is usually set in saggers to protect it from the flames of the fires in the kiln.

SAW, CIRCULAR, BAND, ETC., POWER DRIVEN, see Saw, wood.

548—SAWDUST, USES FOR.—Sawdust is added to clay to make the burned ware more porous and of a lighter body than usual. This is accomplished by the fact that the sawdust burns off at the firing temperatures reached in the kiln, leaving the burned ware in a very porous condition. Sawdust is used in making terra cotta lumber, hollow tile, and to produce a light weight refractory brick.

540—SAW, HACK, ALL TYPES.—A hack saw is an appliance for cutting and sawing metal. There are two general types, namely hand and power hack saws. In each type the blade is the important feature. Hack saw blades are thin strips of tough steel that have highly tempered teeth on one edge. These teeth resemble those on a wood saw except that they are much smaller. Near each end of the blade there is a hole for fastening the blade to the frame or attachment by means of which it is pushed and pulled back and forth. The frame for using hand hack saw blades forms a rectangle when the blade is in place, and the handle is attached to one end in line with the blade. Many of these frames are adjustable to any length of blade. In placing a blade in a frame it should be set so that the teeth will cut as the saw is pushed forward, and the saw should be slightly raised as it is pulled backward. The teeth are not set to cut either way as in a wood saw and pulling the teeth over the metal with any pressure on them will result in damage to the teeth. A power hack saw is practically the same as a hand hack saw except that it is usually driven by a belt instead of by hand. A power saw automatically lifts the blade on the return stroke. A power saw needs no attention after it once starts on a cut, as the material to be cut is clamped down and when the cut is finished the clutch is automatically disengaged. A power saw also pumps a special oil over the blade to keep it cool while cutting. Care must always be exercised in placing a hack saw blade in either a hand frame or a power saw to be sure that the blade is of the right tautness. A blade is too highly tempered to permit of any bend and if the frame is not tightened sufficiently the blade will soon become cramped and break. The same care must be exercised when a hand saw is used. The blade must be kept in the same plane as the cut or the life of the blade will be very short.

550—SAW, WOOD.—A saw for cutting wood is either a hand saw or a power driven saw. The former consists of a steel blade that is pliable and tough. One edge has teeth that are sharpened and spread both ways so that the width at the points of the teeth is about twice as much as the thickness of the blade. Hand wood saws are usually used by one man but two-man saws are made that have a handle on each end.

Power wood saws are usually driven by a belt or geared electric motor. The saw may consist of a circular plate which revolves at high speed and has teeth on its periphery. This is called a circular saw. A band saw is one that consists of a band about one-quarter to three-quarters of an inch wide and approximately 25 feet long. The length, however, may vary either way as it is not important. This band revolves around two pulleys and passes a table in such a way that a piece of wood can be sawed by pushing it against the teeth that are cut into one edge of this band. Band saws and circular saws offer large chances for accidents, and they should by all means be equipped with safety devices.

551—SCALES.—Scales are used for many purposes around a clay products plant. Some plants buy their raw material and coal by the ton and use a wagon scale for this purpose. Wagon scales are also useful where it is desired to ascertain the amount of coal being consumed at a boiler room or in the kilns. Again some plants sell their ware by weight, and if it is hauled a wagon scale is necessary. Wagon scales are made with a platform large enough to accommodate a wagon or auto truck, and have a beam located in a scale house which indicates the amount of the load. Some types of wagon scales are made to print the amount of the load on a card, so that any chance of error in copying the figures is avoided. Track scales for weighing full and empty railroad cars are used by many plants, especially where the weight of the ware governs the price, or where the plant is located at some distance from a track scale owned by a railroad. Platform scales handling up to 1,000 lbs. are used for checking up on receipts of purchased material, local shipments, etc. In silica brick manufacture, in the pottery, chinaware and other high grade classes of clay production, platform scales are necessary to insure the proper amount of each ingredient of raw material. Automatic scales for the weighing of the clay as it comes from the mine so as to determine the tonnage mined, are also in use. (See also Poidometer.)

SCHOOL, CERAMIC, see Ceramic school.

SCOOP, HAND, see Shovel and scoop, hand.

552—SCRAPER.—The scrapers used in the clay products industry are similar to the regular wheeled scraper, altho usually of a heavier type. They are used to remove overburden, gather surface clay, and frequently for digging soft shale or fire clay. Under certain conditions a wheeled scraper is more efficient than the regular drag scraper, and at times a "buck scraper" is found being pulled by four or even eight horses.

A drag-line excavator consists of a heavy scraper which is made to dig, haul its load and dump by means of wire rope.

MANUFACTURERS (see catalog section):
Stevenson Co.
Toronto Foundry & Machine Co.
Green, L. P.

SCRAPER, DRAG, POWER, see Excavator, drag-line.

SCREEN, PIANO-WIRE, see Piano-wire screen.

553—SCREEN PLATE.—A screen plate is a perforated plate of metal which is placed in the revolving bed of a dry pan. Thru its perforation passes all of the clay or shale ground by the pan. There are usually six or eight of these plates in a pan, and they are placed so as to form a circle on their outer edge. The clay or shale is ground by the mullers wearing and rolling on the solid bed plates, and the centrifugal force carries the ground clay onto the screen plates. If it is ground fine enough it passes thru these plates and into the elevator, but if not fine enough scrapers are provided to push it back under the mullers again. Screen plates are subject to great wear on the top surface and in the perforations. If the perforations become too large trouble is encountered in the succeeding processes. For these reasons screen plates are made of as hard material as practical. Almost all are made of white iron, chilled cast iron, cast steel or manganese steel. Some are made of wrought iron bolted together to form and act as one piece. (See Manganese steel and Pan, dry.)

MANUFACTURERS (see catalog section):

Bonnot Co.
Eagle Iron Works.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Stevenson Co.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

554—SCREEN, REVOLVING.—Revolving screens are of two principal types, cylindrical and polygonal. The cylindrical screen is sometimes modified to the frustum of a cone. The polygonal is made with a varying number of sides, and its cross section may be anything from the square to the dodecagon. The clay enters at one end, which is elevated, and gravitates to the lower end. As the screen revolves, the fine material passes thru the mesh of the screen, while the coarser material passes out thru the lower end and is returned to the pan for further grinding. The revolving screen is generally mounted on a timber frame in simple bearings, and provided with ample oiling devices. The frame may be covered with perforated steel plates or with wire gage with any size of opening desired, the usual size being 1/8 to 1/20 in. The screen is usually four to nine feet long, some are as long as 20 ft., the average length being six feet. Generally, the cylinder works satisfactorily at 12 r. p. m.

There is another type of revolving screen which consists of about 12 or 15 plates about three feet wide and five feet long. These plates are mounted on a set of chains that revolve around sprockets. The plates are fastened to the chains on the ends, and when not revolving the screen looks like a perforated sheet screen on top, as it is inclined. When the screen is started the plates are pulled down the incline by the chains, the lowest screen plate is finally turned around the sprockets and starts back up the lower part of the screen to take its place at the top of the screen. At the same time another plate is turned into position at the top of the screen and starts its travel down the incline of the screen. The plates, therefore, successively move down the incline screening the clay as they move, then turn at the bottom, go up on the lower part of the screen and go over the upper sprockets to take their places again in the inclined space. Brushes are provided to clean the plates and in cold weather steam pipes are added. Any type of opening can be used in the plates.

MANUFACTURERS (see catalog section):

Bonnot Co.
Clearfield Machine Shops.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Webster Mfg. Co.
Weller Manufacturing Co.
Williams Patent Crusher & Pulverizer Co.

SCREEN, ROLLED SLOT, see Perforated sheet metal.

555—SCREEN, STATIONARY.—The inclined stationary screen is most frequently used for screening clays and cements. This type of screen consists usually of a rectangular trough, the bottom of which may be covered either with a woven wire screen, a piano wire screen or a perforated metal screen. Its length varies from 6 ft. to 14 ft. and upwards. The trough is inclined at an angle of, say, 30 to 45 deg., according, first, to the size of particle that is to pass thru the screen mesh, second, to the type of screen itself, and, third, to the condition of the clay. The sides of the screen are generally about nine inches high, and a canvas or sheet metal cover is placed across them to prevent loss of dust. A metal or wooden spreading plate, and possibly one or more baffle plates, may be used to insure distribution of the clay over the full width of the screen and thereby to obtain maximum screening capacity. Ordinarily, the clay is brought up by an elevator from the grinding apparatus and dumped onto the upper end of the screen. Its fall over the screen is due to gravity alone, and at a certain inclination will have a definite velocity, and, hence, a specific maximum size of particle will pass thru the mesh under the conditions. The fixed screen has the advantage of simplicity of construction and low initial cost, but constant attention is required to keep it clean.

There are several modifications of the described type, but the details of design and operation remain practically the same in all types. (See Perforated sheet metal; and Piano wire screen.)

MANUFACTURERS (see catalog section):

Bonnot Co.
Clearfield Machine Shops.
Freese, E. M. & Co.
International Clay Machinery Co.
Link-Belt Company.
Newark Wire Cloth Co.
Weller Manufacturing Co.

556—SCREEN, VIBRATING.—The vibrating screen is usually a rectangular trough, built either of steel or wood, equipped with either woven wire, piano wire or sheet metal screens, and set at such a low angle of inclination (from 10 to 15 deg.) that mechanical aid is used to cause a continual downward movement of the stream of clay. The screens are seldom more than 4 ft. wide or over 12 ft. long; generally, they are about 3 by 8 ft. Either a longitudinal or lateral movement may be given the screen by eccentrics, cranks or hammers. The clay is brought up by an elevator from the grinding apparatus and dumped into the upper end of the screen. If the impulse given the screen be longitudinal, the clay is gradually carried downwards by repeated little jars in the direction of vibration. If the vibration be transverse, the clay is thrown from side to side and moves to the lower end of the screen more slowly. The repeated jar thus imparted with each movement also tends to keep the screen mesh open. In some makes of vibrating screens, the design is such that from two to four meshes are used simultaneously. Thus, by using a separate discharge outlet for the size of particle delivered by each screen, "oversize," "undersize" and "intermediate" sizes of screened material may be delivered to as many different sources of consumption or points of storage. Vibrating screens are fitted with canvas or sheet metal covering to prevent loss of dust. (See also Perforated sheet metal; and Sieve, testing.)

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
Link-Belt Company.
Mueller Machine Co., Inc.
Newark Wire Cloth Co.
Robinson, Frank H.
Stevenson Co.
Weller Manufacturing Co.

SCREW CONVEYOR, see Conveyor, screw or spiral.

SCUM, see Calcium carbonate; Calcite; Dryer-white; Soluble salt; Soluble salt, prevention of; Barium carbonate and Kiln-white.

SEGER CONES, see Cones, pyrometric.

557—SEGER PORCELAIN.—A body of composition approximating clay substance, 25, feldspar, 30, quartz, 45 parts, used principally for the manufacture of art pottery (see also Chinaware; Porcelain, soft, Seger's).

SEGGAR, see Sagger.

558—SEPARATOR, CLAY, CENTRIFUGAL.—A small device used to measure the various sizes of grains a clay contains by centrifugal separation. The apparatus consists of a fan-motor placed with the armature shaft in a vertical position; this carries a framework with eight test-tube holders, trunnioned so they can swing outward and upward as the frame revolves. The disintegrated sample of clay in suspension in water is placed in the tubes, and whirled at a high speed for several minutes. This action causes all particles except the finest grains to be precipitated to the bottom of the tube by centrifugal force; the fine grains then being poured off, the tubes refilled with water, and the sediment again stirred up. The second twirling, for a shorter time or at a lower speed, precipitates everything except the fine silt, which is likewise decanted off. The subsequent sizes are then mechanically separated from each other, partly by settling and partly by means of sieves. A very fine degree of separation can be obtained by this means, the particles in the finest possible lot ranging from 1/5,000 to 1/25,000 of an inch in diameter, and those in the coarsest lot from 1/12 to 1/25 of an inch, with a number of intermediate lots each composed of particles of approximately the same size. (See also Elutriator.)

559—SEPARATOR, OIL, STEAM, ETC.—A separator is an attachment or fitting placed in a pipe line to remove certain impurities. A steam separator is intended to remove all of the water which has accumulated in a steam pipe. If the pipe is leading to an engine the separator is placed just above the throttle valve, so that only dry steam is allowed to go into the cylinder. Water in steam reduces the expansive power, and increases the danger of a knock in the cylinder and even the blowing out of the cylinder head. An oil separator is intended to separate all of the oil which is found in exhaust steam, the oil having become intimately mixed with the steam in the engine cylinder. When the exhaust steam is condensed and used again in the boiler, it is necessary to remove this oil to prevent "frothing" and other troubles in the boiler.

559A—SETTING CONVEYOR.—This is a belt conveyor which is used to pick up the ware from a car or barrow and convey it to the setter. The object and advantage is to do away with the labor of tossing.

MANUFACTURER (see catalog section):

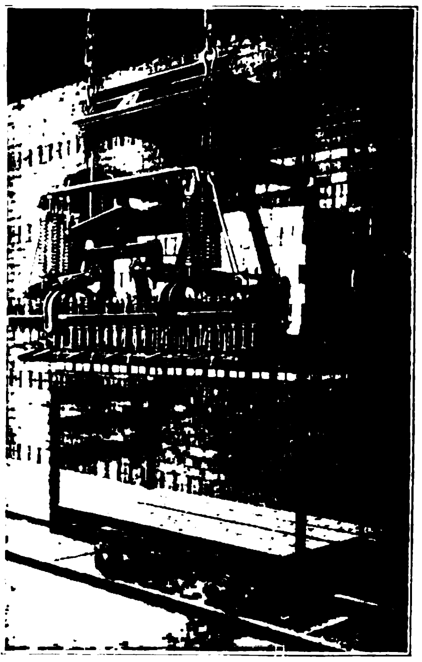
Freese & Co., E. M.

MANUFACTURERS' ANNOUNCEMENTS:

Freese & Co., E. M., Galion, Ohio. Brick setting elevator and conveyor—a portable conveyor which receives the brick from the dryer car and elevates them to a position convenient to the setter. Eliminates tossing.

SETTING DOWN-DRAFT AND UP-DRAFT KILNS (see Kiln, down-draft, methods of setting; also Kiln, up-draft, methods of setting).

560—SETTING MACHINE.—In order to obviate and reduce as far as possible the labor of setting brick, a patented mechanical brick setter has been developed which is suited to handle dry-press, stiff-mud, or soft-mud brick. The brick are hacked on cars according to a standard plan, the bot-



Setting Machine Handling 1,000 Brick.

tom rows being spaced so that equal distances are formed between the brick. The setting machine has a number of fingers which are inserted in the spaces left, as already explained, in the bottom row of brick on the dryer car. On each of these fingers you see there is a series of grip plates. As soon as the fingers are inserted in these spaces and the machine is raised by the crane all the weight of this load, except the grip courses, rests on the top of these fingers. The weight of this superimposed load on the fingers causes these grip plates to be automatically pushed out and exert sufficient pressure on the bottom row of brick to hold them in place. This load is then raised by the crane and placed in position in the kiln. As soon as this load finds its resting place in the kiln the weight of the brick, of course, is released from the setting machine. The pressure of the grip plates is thus automatically released and the fingers are perfectly free to be withdrawn. One man operates the crane and two helpers complete the crew. These three can set one carload or from 800 to 1,000 brick per minute, and under favorable conditions can replace 20 or more men. In addition to the lower labor cost the machine increases the quality of the brick because of the absence of handling. The loss from this cause is very large in some plants.

This machine when used with the equipment described under the items headed Hacking machine, Soft mud brick automatic dumping attachment and Loading machine, makes a brick plant thoroly mechanical and automatic. The brick are not touched by any man at any point of the process. The patents on this machine are owned and controlled by the American Equipment Co., 1619 Conway Building, Chicago, Illinois.

MANUFACTURERS (see catalog section):

American Equipment Co.
Hadfield-Penfield Steel Co.

561—SEVRES PORCELAIN.—A reproduction of the very white, translucent ware produced in Japan, and characterized by a high feldspar and low clay content (also see Chinaware and Porcelain, all items).

562—SEWER PIPE.—These are the straight pipes, elbows, curves, junctions, traps, etc., made of clay, used for drains and sewers. They vary in inside diameter from 3 to 42 inches, and one end of each piece is made with a socket so that the pipes can be joined together in a continuous line and the space between the socket of one pipe and the end of the other filled with some packing material to make it water-tight. The length of the pipes is 24, 30 or 36 inches, and the thickness of the wall from a half inch for the three-inch size to three inches for the 42-inch size. There is also a double strength pipe made for all sizes of 12-inch diameter and larger. Sewer pipe are made of any vitrifiable shale or clay, sometimes with the addition of a low grade fire clay, that has silica in the proper proportion and composition, and will be able to stand enough heat to enable the fumes or gases that arise from the salt that is put upon the fire to combine chemically with this silica to form a glaze or glass on the surface. Sewer pipe is always made on a steam press. (See also the item Sewer pipe clays under classification Clay.)

SEWER PIPE BARROW, see Barrow, sewer pipe.

SEWER PIPE CRANE, see Kiln crane.

SEWER PIPE DIE, see Die, sewer pipe.

SEWER PIPE PRESS, see Steam press.

SEWER PIPE, SALT GLAZED, SURFACE PIMPLING OF, see Salt glazed sewer pipe, surface pimpling of.

SEWER PIPE TURNER, see Turner, sewer pipe.

SHAFT COUPLING, see Coupling, shaft.

563—SHAFTING.—Shafting is composed of a number of connected steel bars, usually solid and cylindrical in shape, which are used to support pulleys, flywheels, etc., or to transmit power or motion by rotation. Large shafts are sometimes made of hollow steel bars. The shape may also be square, hexagonal or octagonal. Shafting is supported by bearings or hangers, containing boxes lined with babbitt metal, rollers or balls.

MANUFACTURERS (see catalog section):

Caldwell Co., W. E.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.
Stevenson Co.
Toronto Foundry & Machine Co.

564—SHAFTING, HANGERS FOR.—Shaft hangers and pedestals are usually some form of heavy cast-iron or steel bracket which may be bolted to wall, ceiling or floor, each hanger containing a bearing to support and facilitate the operation of the revolving shaft. Most of these bearings are lined with babbitt or other anti-friction metal. Lately, however, roller bearings for shafting have been installed in many instances, greatly reducing the friction, with a consequent saving.

MANUFACTURERS (see catalog section):

Caldwell Co., W. E.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Mueller Machine Co., Inc.
Stevenson Co.
Toronto Foundry & Machine Co.
Webster Mfg. Co.

565—SHALE.—That form of clay which has a rock-like and in most cases a decided laminated or stratified formation. It is essentially red burning, and has a burning range slightly higher than surface clay. It is used extensively in the manufacture of building, face and paving brick, sewer pipe, hollow and drain tile. Most profitable shales have a long vitrification range. All must be ground in a dry pan, hammer crusher, roll crusher or disintegrator before being used, depending on the softness of the shale, the amount of impurities present, its plasticity and the ware to be manufactured. Shales are usually colored grey, blue or red in the raw state, but this color gives no indication of its properties.

SHALE PLANER, see Planer, shale.

566—SHAPER.—A shaper is a machine for cutting or dressing flat surfaces of metal, in which the metal to be worked on is fastened to the stationary bed and the cutting tool reciprocates. It is the opposite of a planer but is built to take care of smaller work than a planer. The bed is perfectly level and can be fastened at any height, and it can also be moved sideways within certain limits. The tool is mounted on a reciprocating carriage which is above the work and has long bearings to insure the tool moving in the same plane. The carriage is adjustable both in speed and length of travel. The tool cuts only as it goes forward, and the speed of the return motion is much faster than that of the forward motion. Either the tool or the bed, but not both, can be made to automatically feed sideways and vertically. The cutting tools are made of tool steel shaped to make the type of cut desired, and at times it is advisable to replace the cutting tool with a grinding wheel driven by a motor. Shapers are suited for finishing any flat surface of metal, and grooves or offsets in a flat surface. See Grinding wheel; Planer, machine.

567—SHED, DRAIN TILE.—Used for natural drying. Commonly the shed is about 14 ft. wide and equipped with racks, placed on either side, with a passageway thru the center of the shed serving as a truck runway. Steam pipes under the racks, or other artificial methods of heating, are frequently used to assist the drying. The tile are placed on pallets four or five feet long, and racked the same as brick pallets.

SHEET METAL, PERFORATED, see Perforated sheet metal.

SHEET PACKING, see Packing, sheet.

568—SHOVEL AND SCOOP, HAND.—The manufacture of hand shovels has, in recent years, become a specialized business, many differences in design, size and weight, and of materials used in construction, having been made; first, to enable the shoveler to handle the class of material he is shoveling with comparative ease (and thereby increase his personal efficiency and production), and, second, to increase the life of the shovel under the specific conditions under which it must be used; e. g., the pointed scoop shovel for handling crushed rock, coarse gravel, etc.; the regulation scoop shovel for coal and grain; the long-handled, muck stick mining shovel for wet clays, etc., with a variety of intermediate models for other classes of duty.

569—SHOVEL, ELECTRIC.—In general, an electric shovel is a counterpart of the steam shovel, except that it derives its power from electric motors, which may be of any type that will operate on the available current. Electric shovels are convenient in cold weather, as a simple switch connection is the only preparation necessary to begin operations. The cost of current consumed, however, may be greater than that of the coal used in a steam shovel. Sizes and capacities vary as with steam shovels. (See also Shovel, power; Caterpillar traction and Shovel, steam.)

570—SHOVEL, POWER.—The power shovel basically resembles the familiar type of locomotive crane, having its digging mechanism mounted upon a rotary bed-plate or turntable and carried, usually, upon a four-wheeled truck. The smaller sizes are mounted either upon wide tired traction wheels or upon car wheels, designed for any narrow gage railway track. The larger and heavier machines are generally mounted on standard gage car wheels. Nearly all makes of steam shovels have self-propelling trucks. Due to improved traction design, modern shovels travel by their own power with comparative ease. Being mounted on a rotary bed-plate or turntable the shovel swings in a circle, delivering the excavated material at any desired point within the radius of its reach. A steel or wooden boom is hinged to the turntable and supported at an angle by guy rods or wires. Provision is sometimes made for raising and lowering this boom by the power of the shovel. From the end of the boom a dipper or bucket is hung and wires or chains provided for raising and lowering it also. In addition the bucket is fastened on the end of a dipper stick which passes back and forth thru the boom. At the place where this dipper stick passes thru the boom a crowding mechanism is provided to push the dipper into the material to be dug at the same time as the dipper is raised by the wires or chain. On the outside edge or point of the dipper, teeth of very hard metal are placed which do the digging and scoop the material into the bucket. When ready to dump the material out of the bucket a catch in the bottom is opened, and the contents drop out. Some of the small types of shovels use a wire rope to pull the bucket into the material instead of the crowding arrangement described above. The bucket travels on a track in this type.

In one type also the crowding mechanism is replaced by an arrangement driven by a wire rope.

Power shovels are operated by one, two or three men, depending on the capacity and size. They are very economical for digging clay or overburden when the average daily output is large enough. Some of the smaller machines will dig an average of 75 tons per day economically, but the larger machines require 200 or 300 tons per day.

Power shovels are driven by steam, electricity, or an internal combustion engine. (See also Shovel, steam; Shovel, electric; Dipper teeth; Caterpillar traction.)

MANUFACTURER (see catalog section):

Link-Belt Company.

571—SHOVEL, STEAM.—A steam shovel is a power shovel which uses steam as the source of power. A steam shovel is the original power shovel and to a certain extent all power shovels today are known as steam shovels. The smaller types are revolving; that is, the entire upper structure or everything above the trucks revolves. The larger machines are usually of the railroad type, in which the body of the machine stays stationary on the trucks, and only the swinging boom which carries the dipper revolves. There are types of large machines which entirely revolve. There are several methods of moving steam shovels. One type uses trucks and runs on rails the same as a railroad car. The rails are about six or eight feet long, and the track is laid as the shovel moves forward. The very large shovels run on rails also, but the gage is larger and the trucks used are not standard railroad trucks. There is also a traction type in which the wheels look very much like those on a traction engine, that is, they have a board tire and do not need any rails.

There is also an improved type of traction which is described under Caterpillar traction.

The mechanism of a steam shovel consists of a vertical or horizontal boiler, several steam engines of the double reversible type, similar to those used on a locomotive, etc. The boilers are usually fired with coal.

Steam shovels are operated by one, two or three men depending on the size. They are very economical for digging clay or overburden when the average daily output can be large enough. Some of the small machines will pay for a daily output of 75 tons but the larger machines require 200 or 300 tons per day.

A 25-ton shovel is capable of moving 200 to 225 tons of clay per day; a 35-ton shovel, 260-325 tons; a 45-ton shovel, 300-600 tons; a 60-ton shovel, 400-1,000 tons. The production depends upon the size of the dipper used, the nature of the clay, and its accessibility. The dipper, or bucket, generally ranges in capacity from ½ yd. to 3½ yds. (See also Shovel, power; Shovel, electric; Dipper teeth; Caterpillar traction.)

572—SHRINKAGE.—All clays shrink during drying and burning; the first stage is known as air-shrinkage; the second, as fire-shrinkage.

In drying clay, the air-shrinkage is due to the settling together or slipping of the clay particles when the water is evaporated. Consequently, the larger the amount of water necessary to make the clay mass plastic, the greater the shrinkage is found to be. For example, air-shrinkage is usually low in sandy clays, at times being under 1% in coarse sandy clays, while it is high in very plastic clays or very fine-grained ones, amounting at times to as much as 12 or 15%. Generally speaking, the finely grained clays shrink more because of the great number of minute grains to be surrounded with water; but the clays are usually the more plastic and strong and better able to stand excessive shrinking without cracking. All clays, however, that require a large amount of water in mixing do not show a high air-shrinkage, since the latter will vary not only with the amount of water added, but also with the texture of the materials.

Fire-shrinkage, like air-shrinkage, varies within wide limits, the amount depending upon two conditions: (1) the quantity of volatile elements the clay contains, such as combined water, organic matter, and carbon dioxide; and (2) the texture and fusibility of the clay. Fire-shrinkage may begin at a dull red heat, or at the point where the chemically combined water begins to pass off, and reach its maximum when the clay vitrifies, but does not increase uniformly up to that point.

According to Wheeler (Mo. Geol. Surv., Vol. XI, p. 121, 1897) the most potent factor in fire-shrinkage is the size of the grain; the finer the grain, the greater the fire-shrinkage, and vice versa.

An accurate knowledge of the air- and fire-shrinkage of a raw clay is absolutely necessary to correct and successful practice in drying and burning, and to produce a burned ware of the required dimensions.

The linear shrinkage for drying is calculated from the formula

$$a = 1 - \sqrt[3]{1 - \frac{b}{100}} \times 100$$

in which a=per cent. linear shrinkage
b=per cent. volume shrinkage

In reporting drying shrinkage, the following information shall be given and these values shall be the means of results obtained on two test pieces:

(1) volume shrinkage in percentage of the dry volume.

(2) linear shrinkage in percentage of the dry length.

For determining shrinkage water see Plasticity, measurement of. (See also Clay Testing; Volumeter; Density; and Porosity.)

The American Ceramic Society Uses the Following Standard Test for Shrinkage.

(1) Size and Shape of Test Pieces.

The test pieces shall be made approximately 30x30x45mm (1⅛x1⅛x1⅞ inches). It is apparent that the dry dimensions will vary with different clays.

(2) Preparation of the Clay.

The clay shall be thoroly dried at a temperature above 64 deg. C., but under 76 deg. C. and crushed to pass a standard No. 20 sieve. It shall then be made up with water to a soft, plastic consistency and thoroly wedged and kneaded by hand. This consistency will permit of the careful handling of the piece immediately after forming.

(3) Making Test Pieces.

The test pieces shall be made in a suitable metal mold measuring approximately 30x30mm (1⅛x1⅛ inches) by any desired length. After making, the pieces shall be cut into 45mm (1⅞ inch) lengths. The mold shall be thinly and evenly oiled with kerosene or a light machine oil only as frequently as is necessary to keep the clay from sticking. The test piece shall be formed by taking in the hand a lump of clay, somewhat larger than required to fill the mold, and kneading it into a roll approximately the length of the mold. It shall then be placed in the mold and forced into the corners by blows with the cheek of the fist. The excess shall then be struck off with a wire and the piece slicked with a spatula and approximately marked or numbered for identification. Care should be taken by the operator to keep his hands free from oil. The test piece shall be removed from the mold immediately and transferred to a smooth, straight pallet, care being taken not to distort it.

If preferred the test pieces may be made in a piston plunger press fitted with a die 30mm (1⅛ inches) square. In either event the corners of the test piece shall be slightly rounded.

(4)—Plastic Volume.

The plastic volume shall be determined immediately in a volumeter of the Seger type. Kerosene with a specific gravity of about 0.8 shall be used as the measuring fluid. The volume shall be read to the nearest 0.1 cc.

(5) Drying.

After the plastic volume is determined the surfaces of the test pieces shall be dried lightly with a soft cloth to remove the film of kerosene, and allowed to dry at room temperature until air dry. They shall then be dried at a temperature between 64 deg. C. and 76 deg. C. for at least five hours and finally at 110 deg. C. to approximately constant weight. They shall not be allowed to cool to room temperature between these two drying operations unless they be placed in a desiccator. After the final drying treatment they shall be placed in a desiccator to cool and remain there until the test is continued.

(6)—Dry Volume.

The dry test pieces shall then be allowed to soak in kerosene of the same specific gravity as that used in the volumeter for at least 12 hours, after which the volume shall be determined in the same manner as specified for the plastic volume in article 4. The volume shrinkage shall be calculated by the following formula:

$$b = \frac{V_p - V_d}{V_d} \times 100$$

in which b=per cent. volume shrinkage
V_p=the plastic volume
V_d=the dry volume

574—SIDERITE.—The carbonate of iron ($FeCO_3 = FeO$ 62.1%, CO_2 37.9%); occurs in clay in three forms: (1) Concretionary masses, or clay-iron-stones, which may vary in size from a fraction of an inch in diameter to several feet. These are abundant in certain carboniferous shales, being frequently strung out in lines parallel with the stratification of the clay. When near the surface, siderite concretions frequently change to limonite. (2) Crystalline grains, scattered thru the mass, and seldom visible to the naked eye. (3) As a film which covers or coats other minerals in the clay; also changes to limonite if exposed to the weather.

If iron carbonate is finely divided and evenly distributed thruout the clay, a blue or slate-gray color may result.

Siderite is probably of greatest importance in shales, particularly those affiliated with coal seams, and may be found either in a finely disseminated or concretionary form.

575—SIEVE, TESTING.—Testing sieves are small sieves or screens, used to determine the proportions of ground clay that will pass thru each mesh. They are made round or oblong, some for hand or portable use, and others for use in connection with small screening machines, which are fitted with shaking attachments. The screens are made of perforated sheets for the coarser sizes, and wire cloth made of steel or brass wire, for the finer sizes. They are made as fine as 200 mesh. For very fine sieving, lawn cloth is used. (See also Lawn.)

MANUFACTURER (see catalog section):
Newark Wire Cloth Co.

576—SIGNALLING SYSTEM OR CALLING DEVICE, INTERDEPARTMENTAL.—These consist first of the branch telephone systems which have stations located at various points thruout a plant or office. A telephone system can be connected to the main lines entering the plant from outside or it can be a system which is limited to the office and plant itself. Either one can be arranged to have very loud bells or calls located so that a man can be reached at any point in a plant irrespective of the noise of the machinery or other disturbance. There are other calling systems in use in which a current generated by pushing a button causes a strong and piercing sound within a horn, similar to automobile signals but sharper and more piercing if desired. By a system of long and short signals any system can be made as comprehensive as desired.

SILENT CHAIN BELT, see Belt, silent chain.

577—SILICA.—A mineral compound of one atom of silicon and two of oxygen (SiO_2), present in clay in two forms: (1) uncombined, as silica or quartz, and (2) in silicates, of which there are several. The most important of these is the mineral kaolinite, which probably occurs in all clays, and is termed the clay base or clay substance. The other silicates include feldspar, mica, glauconite, hornblende, garnet, etc. (see these items).

The free silica or quartz is one of the commonest constituents of clay, and ranges in size from particles visible to the eye down to the finest grains of silt. It is very refractory.

With the exception of kaolinite, all of the silica-bearing minerals mentioned above are of sandy or silty character, and, therefore, their effect on the plasticity or shrinkage of the clay will be similar to that of quartz. In burning clay, however, the general tendency of all is to reduce the shrinkage, but their behavior in this respect is more individual. (See also Sand, and Quartz.)

578—SILICA BRICK.—These are used widely in construction of by-product and beehive coke ovens, open-hearth furnaces, iron blast furnaces, in the copper smelting industry, etc. Their physical property of regular expansion peculiarly adapts them to the construction of modern furnaces which do not require a basic material as the lining. The best silica brick are made from pure sandstone or quartzite. The composition of the best stone is: Silica, 98.31%; Al_2O_3, 0.72%; Fe_2O_3, 0.18%; CaO, 0.22%; alkalies, 0.18%; moisture, 0.35%. The rock is coarsely ground, mixed with 2 to 3% lime in the form of a milk of lime, and then molded into shapes. They are burned in kilns at a temperature sufficiently high (cone 17-18, 2,700-2,800 deg. F.) to form a lime silicate which acts as a cement or bonding material. The SiO_2

averages 95.6% on these brick, which are of a coarse texture and rather friable and brittle; they will not stand abrasion and are highly corroded by basic slags.

Refractory brick makers have obtained best results with quartzites. The two chief sources of this material are Wisconsin and Pennsylvania. These average 97% SiO_2 together with alumina, ferrous, and ferric iron. It appears that about 3% of impurities, of which about one-half are oxides of iron, strengthens the brick by the formation of incipient slag particles. Attempts to use pure quartzite have not been conspicuously successful.

MANUFACTURER OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.

579—SILICA, HYDROUS.—From observation of W. H. Zimmer (see Trans. Amer. Cer. Soc., III, p. 25, 1901) it would appear that some kaolins carry hydrated silicic acid. He experimented with a kaolin composed of silica 57.00, alumina 24.85, ferric oxide, 0.25, lime 0.05, and water 17.81, and with artificial mixtures containing silicic acid. The results of his experiments indicate that the presence of any important quantity of free hydrated silicic acid in a clay tends: (1) To produce an increase of translucency over that obtained where the silica used is all quartzitic at equal temperature; (2) to bring about an improvement in color; (3) to increase the shrinkage both in air and in fire; (4) to produce a lowering of the temperature at which vitrification occurs; (5) a tendency to warp in drying; (6) a tendency to form a hard coating on the surface of the clay or ware, due to the deposition of H_2SiO_3 from water used in making wares plastic.

580—SILICA, PERCENTAGE OF, IN CLAYS.—The results obtained from several hundred analyses (see Bull. N. Y. State Museum, No. 35, p. 525) show that the silica content in several classes varies about as follows:

Brick clays: From 34.35% to 90.877%; average, 59.27%.

Pottery clays: From 45.06% to 86.98%; average, 45.83%.

Fire clays: From 34.40% to 96.79%; average, 54.304%.

Kaolins: From 32.44% to 81.18%; average, 55.44%.

SILICON-CARBIDE, see Carborundum.

581 — SILO-BLOCK MACHINERY. — The machine used to form the column from which silo blocks are cut does not differ materially from the machine used for any hollow tile. The cutter does differ somewhat, however. Silo blocks are longer on the outside of the circle than on the inside and the joints are not made square with the inside or outside of the block. To accomplish this the cutter has curved pallets instead of flat ones as are used for hollow tile, one pallet having a convex curve to fit the outside wall of the silo, and the next pallet having a concave curve to fit the inside wall of the silo, and the pallets alternate this way continually. The cutting wires cut on an incline, one wire cutting at an angle to the perpendicular one way and the next wire cutting at an equal angle the other way. The result is that the blocks are all alike, one block coming off of the cutter with the inside on top and the next with the outside on top. (See Stiff-mud brick machinery; Auger machines; Plunger machine.)

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
International Clay Machinery Co.

SIL-O-CEL.—The trade name used by the Celite Products Co., of Chicago, for their insulating brick and bulk material.

582—SILOXICON.—A product made in an electric furnace similar to carborundum (see special item), but contains less carbon and therefore has some unreduced silicon. Its composition varies, but it may be represented by the formula Si_2C_2O. This material is crushed, made into blocks and bricks, and burned at high temperature. This material oxidizes slowly above 1,470 deg. C. (2,678 deg. F.), and is used as a refractory substance in lining copper and brass furnaces, some electric furnaces and to some extent clay and zinc retorts.

583—SINKING FUND.—This is a sum of money which is set apart at definite intervals in definite amounts, in order that at a certain future time the principal and interest will equal a certain amount. It may be the intention to use the gross amount for any purpose, for instance, the retirement of a bond issue or other debt. A sinking fund is often used to take care of depreciation, and in that case it is sometimes the sum of several items of depreciation at various rates. The omission of a sinking fund is liable to create an erroneously good showing of profits.

583A—SLABBING OF SEWER PIPE AND DRAIN TILE.—This trouble causes serious losses at times at some plants. After consideration by experienced men the remedies to be tried for this trouble can be summed up as follows: Add grog to the clay if it is fine grained or pressed so tightly that care in the several stages of burning does not remedy the evil; watch that the press is properly filled; construct the die so that lamination will be reduced to a minimum and no air will be contained between the several layers of clay.

Allow sufficient time for all three of the important stages of burning, namely, watersmoking, oxidation and vitrification.

The use of watersmoking thermometers and pyrometers will assist greatly in avoiding this trouble in the burning. A standard rate at which to raise the heat can be set after the safest rate is determined and all future burns carried along at this proper rate.

584—SLAKING.—When immersed under water, a lump of raw clay or shale falls to pieces or slakes, and the process ceases only when the clay has broken down to a fine powder-like mass. Soft porous clays will slake in a few minutes; tough shales may require several weeks, and may even then be incompletely disintegrated.

The slaking property is of some practical value, inasmuch as easily slaking clays temper more readily; or if the material is to be washed, slaking causes it to disintegrate more rapidly in the log-washer.

Clay will slake the same in open air, the moisture in the atmosphere supplying the water that is necessary. This is really what happens when clay weathers, altho of course the water from snow, rain, etc., is added.

585—SLEEVE, NOZZLE AND RUNNER-BRICK MACHINERY.—Sleeves, nozzles and runner-brick are usually made on a machine similar to the machine used for the manufacture of flower pots. The machine is upright and resembles a drill press in general appearance. The mold or casting to form the outside of these shapes is held on an extension from the main frame in practically the same position as the table of a drill press. It is stationary, however, and the core or casting to form the inside of these shapes is mounted on a spindle which revolves continually. The operator moves this spindle and core up and down while it is revolving. This part of the machine is almost identical with the spindle and drill on a drill press. The clay is prepared in another machine and cut into balls containing the proper amount for the article to be manufactured. These balls are fed into the finishing machine described above, one at a time, and the core on the spindle lowered into place by the operator. When the core is raised the bottom of the mold acts as a plunger and raises the finished piece so that it can be removed and the operation repeated.

MANUFACTURERS (see catalog section):
Baird Machine & Mfg. Co.
International Clay Machinery Co.
Stevenson Co.

SLIP CLAY, see specific paragraph in item Clay.

586—SLIP GLAZING.—The slip glaze is the basis of a naturally occurring clay. It is mixed with water to a creamy consistency and applied to the surface of the ware by dipping or spraying. The clay alone may be used for glazing, or, if it is too refractory for the ware, or if it is desired to modify the color, fluxing or coloring liquids are added. There are several slip clays found in this country. They differ in composition principally in the percentages of fluxes relative to one another. The characteristics of a slip clay may be classified in this manner: Physically, the clay must be very fine grained and free from concretionary matter; the proportion of lime and magnesia must be high, from 6 to 12%; the iron content should be sufficient to produce a good brown color—from 5 to 7%; the clay must be fusible and high in alkaline minerals; it must also have a low shrinkage in drying and must mature in burning as little above 2,250 deg. F. as possible.

Ware with large openings—churns, jars, etc.—is glazed both inside and outside by dipping. Jugs and other pieces of ware having small openings are glazed inside by forcibly pumping the slip thru a nozzle or spray into the jug, the excess being emptied out. Only by the most careful handling can marring the glaze be avoided in transferring the ware from drying shelves to kiln.

587—SLIP MIXING.—When the "charge" is completed, the scale-truck is pushed alongside the blunger mill, into which the materials are shoveled in their so-called dry state. Cobalt stain, which constitutes less than one-tenth of 1% of the total body materials, is added, and the entire mass, with a measured quantity of water, is churned by means of a powerful agitating mechanism within the blunger until all the ingredients are thoroly mixed and reduced into "slip" and in a fluid condition.

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

588—SLIP SIFTING.—After the clay-slip has been thoroly mixed it flows by gravity to a large vat or container called a rough agitator, which continues to agitate it to prevent settling. From this it either flows or is pumped to a sifter machine, the frames of which are covered with silk lawn, 120 threads to an inch, or by closely woven copper wire. The meshes of the sifter retain the coarse and waste materials.

An improved English sifter is built on the revolving principle, with two or three decks, and is self-cleaning.

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

589—SLIP TESTING.—This is accomplished by "straining" a sample of the slip thru a lawn or sieve, the fineness of which will depend on the nature of the material and the purposes for which it is intended. It is also good practice to test a portion of the slip with a magnet at frequent intervals where white bodies are used, so that any particles of iron may be detected when present. (See also Density.)

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

SMOKING, see Burning, water-smoking period of.

590—SOAK-PIT.—This is simply a pit into which the clay, with water added, is put and soaked overnight preparatory to disintegrating, etc., the following day; used chiefly at small yards. (See also Ring-pits.)

MANUFACTURER OF EQUIPMENT (see catalog section):
International Clay Machinery Co.

591—SODA ASH.—A white powder used as a flux by potters. The formula is (Na_2CO_3), and it melts at 849 deg. C. (1,562 deg. F.).

SOFTENING POINT, see statistical section, under fire brick.

592—SOFT-MUD BRICK.—Brick made by the soft-mud process—preferably from alluvian, surface and loess clays—are of necessity less dense than those made by other methods. They are porous when burned, which condition is favorable to good color, and, when fairly hard burned, possess qualities of strength and durability. As no augers are used in the soft-mud process, the brick are usually uniform thruout and free from laminations; also, due to the free mobility of wet clay, defects do not arise from pressing the clay into the molds. Building brick, fire brick and silica brick are the products that are usually made by the soft-mud process.

592A—SOFT MUD BRICK AUTOMATIC DUMPING ATTACHMENT.—This patented automatic dumping device for use in connection with soft mud brick machines has been developed for the purpose of eliminating the hard labor required in the operation of this class of machines and it, also, makes it possible to produce a much better brick and have larger capacity units than was heretofore practical. The attachment consists of a means of feeding the empty molds to the brick machine, and as the filled molds are discharged, it successively bumps, dumps, sands, and returns the empty molds to the machine, while the pallets of brick are carried away by conveyors as fast as made. The only labor required is the operators to attend to the sand and supply of empty pallets and as all the manual labor of handling the molds or pallets of brick is eliminated, it is possible to make molds of any desired size from 6 to 16 brick each, giving the machine capacities of from 75,000 to 150,000 brick per day.

MANUFACTURER (see catalog section):

Hadfield-Penfield Steel Co.

593—SOFT-MUD BRICK MACHINE.—The soft-mud brick machine is built on various plans, horizontal and otherwise. It consists mainly of a pugging mill in the lower part of which clay is forced into molds by means of press plates or plungers actuated by wooden or steel cranks. The molds to receive the clay are set in frames and hold four to eight brick. These molds are fed into the machine from the side immediately beneath the press-box and, when filled, are automatically pushed forward to the "striker-off," who by means of a small wire or blade strikes the clay off even with the top of the molds.

The sanding of the molds is an important part of the process. There are two methods of sanding, by hand and machine. In hand-sanding, the sand is poured into the molds, which have previously been dampened, and the molds are then shaken and the sand dumped out, leaving only enough sand clinging to the molds to prevent the plastic clay from sticking.

The mold-sander consists of a rotary framework into which the molds are placed; the frame is rotated inside of a cylindrical shell in the lower portion of which is sand, filling the molds with the latter and dumping them as they go round. A good grade of fine sharp sand is best for use with mold-sanders.

The soft-mud brick machine is ordinarily located so that the clay is dumped directly into it from above or shoveled into it from an elevated platform. The clay is at this point supplied with the correct amount of water for tempering. The remainder of the operation, as indicated above, is automatic. A soft-mud brick machine using six molds has an average capacity of 35,000 brick per day. The power required depends, first, upon the capacity of the machine; second, upon the nature of the clay used. Soft-mud brick machines are used successfully for making fire brick and building brick.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.

594—SOLUBLE SALT.—Soluble salts in clay may be traced primarily to the decomposition of mineral grains in the clay deposit, this decomposition resulting in the formation of soluble compounds. Those met with most frequently are sulphates of lime, iron, or alkalies, and their presence in the clay is generally due to the decomposition of iron pyrite. If the pyrite is in a finely divided condition and well distributed thru the clay, the quantity of soluble sulphates may be greatly increased; on the other hand, soluble sulphates may be present in the absence of iron pyrite, being formed, in this case, when the carbonates are set free, by the decomposition of silicates, such as feldspar.

Altho soluble compounds formed in the green clay can often be detected by spreading the clay out to weather, causing them to form a crust on the surface of the mass, this weathering does not reveal the total extent of their presence; for in some cases fresh pyrite grains remain in the clay even after mixing, and if the clay is stored in a moist atmosphere, these remaining grains will decompose and yield further soluble material.

When the clay ware is being dried, these compounds are carried with the moisture to the surface of air-dried ware and form a deleterious scum, and frequently a white coating on the clay after it has been burned.

Soluble sulphates may also sometimes be introduced into the clay by the water used in tempering, since only distilled water is actually free from soluble salts. Even the artificial coloring materials sometimes used in clay may be a source of soluble salts.

In burning clay with a sulphurous fuel—for example, coal containing more or less iron pyrite—combustion of the coal expels a part of the sulphur content of the pyrite, and this, uniting with the oxygen present in the kiln, forms sulphuric-acid gas (SO_3). If this gas, as it is carried thru the kiln by convection, is brought into contact with carbonates in the clay, the latter are converted into sulphates, due to the fact that some substances, such as lime (CaO), have a stronger affinity for sulphur trioxide (SO_3) than for carbon dioxide (CO_2).

It is often noted that the ware as it comes from the kiln contains no trace of a deleterious surface coloration or coating, but that later, especially if subjected to moisture, it develops what is known as wall-white. This is probably due to the formation of salts within the body of the ware during burning, and later brought to the surface by the evaporation of any moisture absorbed during rainy weather; or it may come from the mortar, either by the direct introduction of soluble salts from the mortar, or by the reaction between carbonates of magnesium, potassium and soda of the mortar, with the calcium sulphate contained in the brick, thus producing calcium carbonate.

The superficial discoloration produced by soluble salts during drying of the ware is termed dryer-white; the same composition caused the trouble known as kiln-white, produced in burning. Where the surface of the ware, after burning, is covered with a yellow or green stain, it is probably caused by the growth of certain vegetable matter or by soluble compounds of the rare element vanadium.

It is estimated that less than 1% of soluble salts may produce a white incrustation on the clay.

595—SOLUBLE SALT, PREVENTION OF.—According to Ries (see pp. 116-117, Clays: Occurrence, Properties and Uses, pub. by Wiley & Sons, Inc., N. Y.), the following methods have been suggested for the prevention of dryer-white and kiln-white: (1) Use the clay in its unweathered condition, or before the soluble salts have time to form. (2) Use the clay in a thoroly weathered condition, thus permitting removal of salts by leaching. (3) Change the soluble salts to a harmless form by precipitation with barium compounds. (4) Prevent the concentration of salts on surface of brick by rapid firing. (5) Removal of whitewash in the kiln by using a reducing flame. (6) Coat the brick with some combustible substance, such as wheat flour or coal-tar, which burns away with a strong reducing action and removes the whitewash. (Also see Barium carbonate, and Soluble salt.)

595A—SPAR CHINA.—This is the type of china usually made in this country, as distinguished from bone china as made in Europe. The term is not used except when it is desired to distinguish between the two. Feldspar is used in spar china in the same relationship that bone ash or calcium phosphate is used in bone china. Hence the terms.

596—SPECIFIC GRAVITY.—The specific gravity of a substance is the weight of any volume of it divided by the weight of an equal volume of water; hence, the specific gravity of water is 1.00.

Applied to clay, specific gravity refers to the relative density of a clay mass. True specific gravity depends on the mineralogical composition of the clay, and is therefore constant, irrespective of its condition. In practical terms, however, a clay may have one specific gravity when it comes from the bank, and a different specific gravity with each subsequent manipulation, due to the variations of porosity or compactness that are produced in pugging, pressing, drying, burning, etc. The specific gravity of a clay is usually measured by a volumeter. (See this item and also Density.)

For determining the specific gravity of any raw ceramic material the sample shall be taken with the same care and precision as for chemical analysis. For fired materials the sample shall consist of at least two portions of the test piece or ware, from different positions, and the ratio of original surface to volume shall not be greater than in the whole piece.

The sample shall be crushed between hardened steel surfaces, when crushing is necessary, and then ground in an agate mortar, to pass a No. 100 sieve [0.149 mm (0.0059 inch) opening, 0.102 mm (0.0040 inch) wire]. In fired samples or those not likely to contain magnetic material as an original constituent, any magnetic material present after crushing shall be removed with a magnet. About 10 grams shall be prepared in this manner, dried to constant weight at 100 deg. C., and placed in a glass-stoppered weighing bottle.

The picnometer shall be of good quality and workmanship with the mouth ground flat so that there shall be no rounded recess between stopper and bottle when the stopper is in place. The stopper with a capillary tube shall be used.

All weighings shall be made on an accurate chemical balance to the fourth decimal place in grams, with material, and in an atmosphere at a temperature of 20 deg. C. + or — 1 deg. C. The weight of the bottle and stopper dried at 100 deg. C. shall be recorded as "p" and the weight of the bottle filled with distilled water with the stopper in place as W_1.

About two grams of the sample shall be placed in the picnometer (which has been dried at 100 deg. C.) and weighed with the stopper, the weight being recorded as "w." The bottle shall then be filled to approximately one-third its capacity with distilled water, the stopper put in place with a piece of paper between stopper and bottle to prevent sticking, and boiled with care for 15 minutes. The bottle shall then be filled with distilled water to the base of the neck and allowed to cool to 20 deg. C. + or — 1 deg. C. When cool and the sample settled, the filling shall be completed and the bottle wiped dry with a soft cloth.

The true specific gravity shall be obtained by the formula:

$$G_t = \frac{w - p}{(w - p) - (w_2 - w_1)}$$

in which G_t = the true specific gravity,

w = the weight of the stoppered picnometer and sample.

p = weight of the stoppered picnometer.

w_1 = weight of the stoppered picnometer filled with water.

w_2 = weight of the stoppered picnometer, sample, and water.

Two determinations shall be made and reported and they shall check to within 0.005.

596A—SPECIFIC HEAT.—The thermal capacity of a body is the quantity of heat required to raise its temperature one degree. The ratio of the heat required to raise the temperature of a certain weight of a given substance one degree to that required to raise the temperature of the same weight of water one degree from the temperature of maximum density 39.1 is commonly called the specific heat of the substance. Some writers object to the term as being an inaccurate use of the words "specific" and "heat." A more correct name would be "coefficient of thermal capacity."

Specific heats of various substances:

Wrought iron	0.1138
Glass	0.1937
Cast iron	0.1298
Steel (soft)	0.1165
Steel (hard)	0.1175
Water	1.0000
Clay	0.23
Air	0.237
Brickwork and masonry, about	.20

Silica	.191
Corundum	.198
Quartz	.188
Pine (turpentine)	.467
Fir	.650
Oak	.570

SPEED INDICATOR, see Indicator, speed.

597—SPIKE, TRACK.—These are the spikes of steel that are used to fasten rails to wooden ties. There are several sizes graded by the measurement on one side of the square shank or main part. The point is flattened to a chisel point and a head is made on the upper end so that when the spike is driven alongside of the rail the head will catch the flange of the rail and hold it on the tie. The usual size of spike used on narrow gage track is the half inch.

MANUFACTURER (see catalog section):
International Clay Machinery Co.

SPIRAL CONVEYOR, see Conveyor screw or spiral.

598—SPONGING.—A method of decorating the cheapest classes of pottery. The design is cut out of a fine-textured sponge and is used to form designs in the same manner as a rubber stamp.

599—SPROCKET.—A sprocket is a metal wheel which has teeth on its perimeter (or circumference) engaging a chain. The sprocket may drive the chain or be driven by the chain, depending on the function of the shaft on which the sprocket is placed. A sprocket is fastened to the shaft by a key or set screw, the latter not being suited for heavy loads. At times a sprocket is made in two halves, which are clamped onto the shaft by means of bolts. This enables the sprocket to be placed at any point on the shaft desired. Sprockets are usually made of malleable iron. They must be made to fit each individual chain as the teeth must fit the holes provided in the links of the chain, and these vary greatly. Both the sprocket and the chain will wear longer if they fit perfectly. A sprocket and chain-drive is suited to drive elevators, conveyors, etc., or in any place that would require a long narrow belt. It is hard to keep a belt of this description in place, and the chain will cause no trouble. In some cases sprockets and chains are used to drive automatic cutters, and also, at times, in place of an elevator belt. Special links are provided at certain regular intervals and the buckets fastened to them. (See also Buckets, elevator, and Elevators or bucket conveyors.)

MANUFACTURERS (see catalog section):
Caldwell Co., W. E.
Link-Belt Company.
Webster Mfg. Co.

SPROCKET CHAIN, see Chain drive, sprocket.

600—STACK.—A stack is a tall chimney which creates the draft for a kiln or boiler. The kiln stack is universally made of brick or concrete. The concrete stack is usually lined part of the way with fire brick. Very often a stack will draw from several down-draft kilns. This arrangement is made by putting partitions of fire brick at least half way up the stack.

All kiln stacks should be braced to prevent cracking from unequal expansion.

Continuous kilns usually have one large stack built of brick or concrete. A railroad tunnel kiln has no stack in the strict sense of the word. A pottery or enamel muffle kiln of the "bottle" type has the stack built into the top of the kiln by a continuation of the outside wall of the kiln.

The stacks for stationary boiler rooms are of brick, concrete or steel. Steam shovels, locomotives, cranes and other portable boilers use iron stacks exclusively. For a further description of stacks as relating to down-draft kilns see Kiln, down-draft, design and construction of, Kiln, intermittent, round, down-draft.

MANUFACTURER (see catalog section):
Caldwell Co., W. E.

601—STAINING.—Potters' term. Stained ware is produced by adding color to the glaze.

602—STAMPING.—Potters' term; refers to a cheap method of decorating goods that is used largely for cheap gilt decorations. The design is transferred from a slab with liquid gold and transferred to the ware in the same manner that an ordinary rubber name-stamp is used.

STATIONARY SCREEN, see Screen, stationary.

STEAM GAGE, see Gage, pressure.

STEAM PIPE INSULATION, see Pipe covering.

603—STEAM PRESS.—A steam press is a machine for making sewer pipe, large-sized drain tile, conduits, etc. The ware is forced thru a die vertically. Above the die is a cylinder containing a plunger or piston which moves up and down. Clay which has been properly prepared to a stiff mud consistency is fed into this cylinder when the piston is at its highest point. Above the clay cylinder and connected to it is a steam cylinder. In this steam cylinder there is a piston which is connected to the piston in the clay cylinder by several rods. The pistons are propelled by the admission of steam to the upper cylinder, giving it a downward movement which presses the clay thru a die at the bottom of the lower cylinder. The action is then intermittent, the piston receding when it has reached its length of stroke and a supply of clay is needed. The clay previously prepared and in plastic condition is brought to the press on a moving belt. Each time the piston recedes, the cylinder is filled with clay by throwing this belt into motion. The die which forms the ware consists of a central bell or core and outer die, the space between the core and the die determining the thickness of the wall of the pipe. By changing the dies the various sizes of sewer pipe are made. It has been found of advantage to have the issue, or the distance thru which the clay must travel between the dies, compressed to its maximum thickness, quite long—not less than three inches for dies smaller than eight inches, and not below four inches for dies over eight inches in diameter. The basis of this recommendation is that where the issue is short, blebs of air imprisoned in the clay will remain and are apt to form blisters on the pipes, whereas with a long issue the air will back upwards thru the loose clay and escape in the direction of least resistance rather than remain in the clay.

A pipe-table, located beneath the die, receives the pipe as it comes from the cylinder. This table, which is supported by a vertical rod and kept in perfect alignment with the center of the cylinder, is raised and lowered by weights, which may be so adjusted as to counterbalance.

After the pipe is forced out the proper length, it is cut by hand, by wire, or by means of an automatic power cutter, the last forming an integral part of the cylinder mechanism. The length of the piston stroke and therefore the maximum length of the pipe is about four feet. The diameters of the pipes range from three or four inches to three feet.

With plastic clay, traps and bends can also be made on the sewer-pipe press by the use of special dies which have a slide by which the flow of clay from one side to another is regulated.

If it is desired to make brick or a similar product a goose-neck can be provided by means of which the delivery of the ware is horizontal instead of vertical.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
Stevenson Co.
Toronto Foundry & Machine Co.

MANUFACTURERS' ANNOUNCEMENTS:

Stevenson Co., Wellsville, Ohio. In the manufacture of socket pipe-drain tile-flue lining, etc., great care should be taken in choosing the necessary equipment to assure adequate facilities for securing the largest production of satisfactory pieces possible. The pulverizing of raw materials and the tempering of same must necessarily be consistent with the tonnage and quality desired. The press must be fed at high speed and respond instantly to the operator. Our line is complete. We design plant installations.
STANDARD FOR THE SEWER
PIPE INDUSTRY.

Toronto Foundry & Machine Co., of Toronto, Can., manufactures the clay working machinery formerly known as the "Means Clay Working Machinery." Our products are the result of over seventy-five years constant attention to the needs of the clay working industry. We have always been eager to adopt new ideas that would improve our machines. In doing this we have kept away from the many so-called "freak" innovations that were good to look at but were impracticable. We have also put into our machines a plenty of metal and by so doing we have a line of machines that are rugged and will stand up to the most severe service. The great number of favorable reports that we constantly receive prove absolutely that our customers are satisfied. We are ready and willing at any time to give you the benefit of our knowledge and experience in assisting you to solve problems that will confront you. We invite you to write us and avail yourself of this service.

STEAM SEPARATOR, see Separator, oil, steam, etc.

STEAM SHOVEL, see Shovel, steam.

STEAM SUPERHEATER, see Superheater, steam.

604—STEAM TRAP.—A steam trap is used to drain condensed water from a live steam pipe. Its main use in clay products plants is in connection with a dryer that uses steam as its heating medium. In giving up some of its heat to the ware in the dryer, the steam condenses and as the efficiency of the dryer depends on keeping the pipes clear of water of condensation, a steam trap is installed. This is serviceable for dryers in which the steam pipe is directly under the floor as in a tunnel dryer, or equally as good if a fan pulls or pushes air thru a series of coils, from whence it is led under the ware in the dryer. It is equally as serviceable for pipe rack dryers as for automatic stoverooms, mangles, etc. (See also Dryer, steam; Mangle, dipper's; Stoveroom, automatic and Pump, vacuum.)

STEAM TURBINE, see Turbine, steam.

605—STEEL.—Steel was originally produced directly from pure iron ore by the action of a hot fire, which did not remove the carbon to a sufficient extent to form wrought iron. The modern processes, however, involve the fusion of the ore, and the definition of the United States law is that "steel is iron produced by fusion by any process, and which is malleable." Chemically, steel is a compound of iron and carbon generally intermediate in composition between cast and wrought iron, but having a higher specific gravity than either. The following comparison points out the distinctive differences between the three kinds of iron:

Cast iron, per cent. of carbon, 5 to 2, specific gravity, 7.2. Properties not malleable, not temperable.

Steel, per cent. of carbon, 1.50 to 0.10, specific gravity, 7.8. Properties malleable and temperable.

Wrought iron, per cent. of carbon, 0.30 to 0.5, specific gravity, 7.7. Properties malleable, not temperable.

It should be observed that the percentage of carbon alone is not sufficient to distinguish steel from wrought iron; also, that the mean values of specific gravity stated are in each case subject to considerable variation; further, only the hard steels are temperable, the softer grades resembling wrought iron.

"Acid steel" is that made in a furnace having a silicious lining, while "basic steel" is that made in a furnace with dolomitic linings. These terms have no reference to quality and refer mainly to process of manufacture, but the basic process enables ores high in phosphorus to be used, the phosphorus being removed by the addition of lime. Acid steel is slightly stronger than basic steel, owing partly to the higher percentage of phosphorus and partly to the effect of the lime in forming slag in the basic steel. Since 1900 more than three-fourths of the open-hearth steel produced in the United States has been basic; the Bessemer product on the other hand being entirely acid.

The physical properties of steel depend both upon method of manufacture and chemical composition, the carbon having the controlling influence upon strength. Phosphorus increases strength, but it promotes brittleness; manganese increases strength in a less degree, and it promotes malleability; sulphur causes red-shortness, or a tendency of the steel to crumble while being rolled; and silicon increases hardness.

Formulas for Tensile Strength.

Many formulas have been deduced to exhibit the relation between the tensile strength and the chemical composition, but none of these applies to all classes of steel. When the percentages of phosphorus and manganese are known, the following formulas which have been deduced from the exhaustive discussion given by Campbell in 1905 may be used to give reliable results, namely,

$$S_t = 40{,}000 + 68{,}000C + 100{,}000P + 80{,}000CM$$

$$S_t = 48{,}800 + 65{,}000C + 100{,}000P + 9{,}000M + 40{,}000CM$$

the first being for acid and the second for basic open-hearth steel. Here C is the percentage of carbon, P that of phosphorus, M that of Manganese, and S_t the tensile strength in pounds per square inch. For example, acid steel having 0.344% of carbon, 0.045% of phosphorus, and 0.70% of manganese has a tensile strength of 87,200 pounds per square inch; basic steel having 0.344% of carbon, 0.020% of phosphorus, and 0.35% of manganese has a tensile strength of 71,100 pounds per square inch. These formulas do not apply to steel with a percentage of carbon higher than 0.75.

Carbon is the controlling element in regard to strength, and the same is the case with respect to ultimate elongation. The higher the percentage of carbon, within a reasonable limit, the greater is the strength and the less the ultimate elongation. The product of strength and elongation is approximately constant, and hence the ultimate elongation is approximately inversely proportional to the tensile strength.

Classifications of Steel.

Steel is frequently classified, with reference to its uses, and the following is such a classification giving average elastic limits and ultimate tensile strengths in pounds per square inch and ultimate elongations in percentages. For the elastic limit a variation of about 2,000 and for the ultimate strength a variation of 4,000 or 5,000 pounds per square inch from these mean values may be expected. The ultimate elongations are subject to marked variation according to the ratio of the length of the test specimen to its diameter; those here given are for the standard 8-inch specimen.

	Elastic Limit	Tensile Strength	Elongation
Structural steel			
for rivets	30,000	55,000	30
for beams and shapes	35,000	60,000	27
Boiler steel			
for rivets	25,000	50,000	30
for plates	30,000	60,000	26
Machinery steel ...	40,000	75,000	20
Gun steel	50,000	90,000	18
Axle steel	55,000	100,000	15
Spring steel	60,000	125,000	12
Cable wire steel...	100,000	200,000	8

A classification of steel according to the percentage of carbon which it contains and its capacity for taking temper or being welded, is as follows:

Soft, 0.05-0.20C	not temperable, easily welded
Medium, 0.15-0.40C,	poor temper, weldable
Hard, 0.30-0.70C,	temperable, welded with difficulty
Very hard, 0.60-1.00C	high temper, not weldable

It is seen that these classes overlap so that there is no distinct line of demarcation, and in fact the words soft, medium, and hard, are frequently used without precision and only for comparative purposes.

The soft and medium steels resemble wrought iron in having a yield point which is from 2,000 to 4,000 pounds per square inch above the elastic limit, while very hard steels have no yield point. The elastic limit in tension is a little higher than one-half of the ultimate strength. The modulus of elasticity is subject to but little variation with the percentage of carbon, and the mean value of 30,000,000 pounds per square inch may be used in computations for both tensile and compressive stresses that do not exceed the elastic limit. The modulus of elasticity for shearing is about three-eighths of that for tension and compression. Soft and medium steel will withstand a cold-bend test similar to wrought iron, but some of the hard steels will fail to do so on account of their lack of ductility.

The compressive strength of the soft steels may be said to be about the same as the tensile strength, since when this pressure is reached the shortened specimen is badly cracked. The soft steels resemble wrought iron in being plastic under compressive stress exceeding the elastic limit, and some authorities regard the yield point as the compressive strength. Hard steels, on the other hand, are not plastic beyond the elastic limit, but their behavior is like that of brittle materials. The compressive strength of the hard steels is much higher than the tensile strength and in this respect they resemble cast iron; the greatest value recorded is 392,000 pounds per square inch. The shearing strength of steel is usually about 80% of the tensile strength.

The strength of steel may be greatly increased by the processes of forging and drawing. Forging under a hammer or press renders the material more compact and increases both specific gravity and strength. The process of drawing steel bars into wire has a similar result, and wire has been made having a tensile strength of 250,000 pounds per square inch, while the wire used for the cables of suspension bridges usually has a tensile strength of from 150,000 to 200,000 pounds per square inch. By compressing steel while it is fluid, the strength may also be much increased, and this process is used for the steel from which large guns and hollow shafts are made.

Annealing consists in raising cold steel to a light red heat and then allowing it to cool for several days. This process reduces the ultimate strength, but it increases the ductility. As an example, the following table gives some of the results from a large series of specimens prepared by the Bethlehem Steel Co. in 1893 and now kept at Lehigh University; the table refers to flat bars of Bessemer steel. Annealing increases the capacity of steel to resist work.

Tempering consists in plunging heated steel into a bath of water or oil, or by applying these fluids to its surface. The hardness of the steel and its ultimate strength are thereby much increased. Armor plate undergoes special processes of tempering or carbonization which render it excessively hard and tough in order that it may resist projectiles which strike it.

	Tensile Strength		Ultimate Elongation	
Per cent. of Carbon	Lbs. per Sq. In. Unannealed	Lbs. per Sq. In. Annealed	Percentage Unannealed	Percentage Annealed
0.08	58,000	56,000	27	31
0.25	84,000	75,000	21	25
0.50	125,000	99,000	11	19
0.67	136,000	112,000	6	16
1.04	153,000	128,000	3½	11

Steel castings are extensively used for axle boxes, cross-heads, and machine frames. They range in tensile strength from 60,000 to 90,000 pounds per square inch and have an elastic limit of somewhat less than half the ultimate strength. Altho less reliable than steel forgings, they give excellent service after having been annealed so as to increase their ductility and their capacity to withstand shock and work.

Steel is alloyed with chromium, manganese, tungsten, and other materials in order to increase its strength, hardness and toughness. Modern tool steels contain from 5 to 10% of tungsten, which enables the tool to retain its temper even when under a red heat. Nickel is much used as an alloy for the steel of guns and armor plates. Nickel steel has been used to a slight extent for structural purposes and for railroad rails; it contains about 3¼% of nickel, and has an elastic limit of about 48,000 and a tensile strength of about 90,000 pounds per square inch. Nickel steel has been made with an elastic limit of 120,000 and a tensile strength of 277,000 pounds per square inch, the ultimate elongation being about 3%. (See also Tool steel.)

STEEL CABLE, see Rope, wire.

STEEL SHELL KILN, see Kiln, downdraft; design and construction.

606—STEP-PLATE.—A step-plate is the plate which carries the upright shaft of a dry or wet pan, with all of the weight carried by that shaft. This varies from 4 tons to 25 tons, depending on the size of the pan. The bearing or step-plate must therefore be made to lubricate perfectly. A step-plate usually consists of three discs, two of them being chilled cast iron, one fastened to the upright shaft and one fastened to a large casting which forms an oil reservoir. Between these is a bronze disc. The friction occurs between the upper cast-iron disc and the bronze disc, and also between the bronze disc and the lower cast-iron disc. Cut in the faces of the discs are oil grooves designed to give a constant supply of lubricant to the bearing surfaces. The discs run in an oil bath which can be easily replenished. A step-plate should be self-aligning—i. e., it should have one face of one of the discs rounded so that any inequality on the alignment of the pan would be discounted automatically. (See also Pan, dry; Pan, wet, and Pan and Pan Step, how to care for.)

MANUFACTURERS (see catalog section):
International Clay Machinery Co.
Stevenson Co.
Toronto Foundry & Machine Co.

607—STIFF-MUD BRICK.—The term "stiff-mud" denotes the distinction between this and other methods of brick manufacture. For stiff-mud brick the clay is tempered to a stiffly plastic state containing 15-25% water, so that it can be molded, but it will not shape or flow under slight pressure as clay does when prepared by the soft-mud process. The clay, instead, is made of such consistency that it will flow, under heavy pressure, thru a die in the shape of a bar, the latter being strong enough to retain its form even when subjected to considerable strain either longitudinally or laterally. Still, it must be soft enough that, under the pressure of coming thru the die, stratification or lamination produced by the auger will be to the greatest extent eliminated. Thoro preparation of the clay before it comes to the auger machine is essential to the successful manufacture of stiff-mud brick.

608—STIFF-MUD BRICK MACHINERY.—The stiff-mud auger brick machine consists basically of a receiving hopper and a mixing chamber, in which the clay is properly cut, mixed and tempered, and thru which it is forced, by means of revolving knives and an auger, to the brick die at the discharge end of the chamber. The entire machine may be built on a suitable framework of steel, with separate housing for the mixing chamber, the driving gears and the belt-driven, friction-clutch pulley, or the entire base may be a heavy, one-piece casting, arranged to conveniently house all component parts of the machine. Stiff-mud auger brick machines are usually furnished in capacities ranging from 3,500 to 15,000 brick per hour.

By the stiff-mud process the clay is kept just wet enough to stick well together when worked up in a mass, and the brick come from the auger machine stiff enough to be stacked six to ten high. The brick produced have square corners and straight ends, and are perfect in shape and body.

In issuing from the brick machine, the clay stream runs on the cutter belt and is cut by means of wires into proper lengths for brick. On the side-cut machines the clay comes out of the die the proper width and length for brick, and is cut by a side cutter into the proper thicknesses. Generally a sander is so arranged on the die of the end-cut machines that the stream of clay is sanded on the bottom to prevent the brick from sticking to the belt of the cutter, and also from sticking in hacking and burning. Where desirable, the sander is arranged to sand the clay column on all sides.

By the stiff-mud process the clay in some cases can be worked directly from bank into the brick machine, but a better and stronger brick is insured if the clay is thoroly ground and tempered by means of a disintegrator and pug-mill. If shale or material of a hard or flinty nature is used, a dry pan is necessary. The feeder first receives the clay, and from this it drops into the disintegrator, which grinds the lumps, throwing out the rocks. From the disintegrator it falls into the pug-mill, to be tempered and mixed and passed on to the brick machine, which completes the grinding and forms the material into brick.

The nature and condition of the clay determine whether all these machines are necessary to make first-class brick.

MANUFACTURERS (see catalog section):
American Equipment Co.
Bonnot Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Williams Patent Crusher & Pulverizer Co.

MANUFACTURERS' ANNOUNCEMENTS:

International Clay Machinery Company, Dayton, Ohio. Designers of complete stiff mud plants and builders of all necessary equipment. See our pages in catalog section.

Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Manufacturers of the Williams Patented Deck Sweeper Clay Grinder for reducing wet clay and shale direct from bank.

609—STOKER, HAND OPERATED.—These are built like an automatic stoker but are operated by hand. They really are inclined dumping grates, that get the full efficiency out of the coal. The grate part of the stoker consists of a sort of rocker grate instead of a chain grate as in many automatic stokers. The grate is made so that the fire is pushed forward the same as in a chain grate, and the ashes and clinker are dumped at the back. They are used in boilers and in kiln fire boxes with very good success.

610—STOKER, MECHANICAL. — Mechanical stokers, in combination with the use of a forced draft, are employed in large steam power plants to provide means for feeding the coal to the furnaces at a constant, slow and steady rate of delivery, the arrangement being such as to insure the most efficient burning of all the combustible gases distilled from the fuel. Stokers eliminate smoke to a great extent and generally increase the efficiency of the plant, incidentally cutting down or completely eliminating many of the wasteful practices of hand-firing. Stokers may primarily be divided into four classes: (1) traveling and chain-grate stokers, (2) overfeed stokers, (3) swift-throwing stokers, and (4) underfeed stokers. There are numerous advantages claimed for each type, due to the distinctive features which each manufacturer incorporates in his product. Full consideration of all conditions peculiar to his plant should be given the subject by the clayworker before he decides upon which type to buy.

611—STONEWARE.—Pottery made of vitrifiable clays, usually a low-grade fire clay, frequently semi-refractory in character, having a vitrified body, sometimes of bluish color but never white. The surface is glazed. (See also Stoneware clays in classification of Clay.)

MANUFACTURER OF EQUIPMENT:
Baird Machine & Mfg. Co.

612—STONEWARE, ARCHITECTURAL.—This line includes such stonewares as are used in the construction and decoration of buildings. Their impermeability and hardness give them some advantage over terra cotta, but this is somewhat counterbalanced by the difficulties encountered in manufacturing, particularly of the tendency of stoneware to lose its proper shape when being burned. Architectural stoneware may be dull or covered with a salt or other glaze, very beautiful decorative effects being obtained by the use of transparent or colored glazes, which harmonize better with architectural decoration than the harder tones of opaque enamels.

613—STONEWARE, FINE, COMPOSITION OF.—According to E. Bourry (see Searle's trans. ed., A Treatise on Ceramic Industries, 1911, p. 430), in England, feldspathic faience, fine stoneware, and bone china are similar to one another, being manufactured by the same methods and burned at about the same temperature, so that it is often difficult and sometimes impossible to distinguish them, one from the other. The raw materials of fine stoneware are the same as those used for feldspathic faience, but the proportion of Cornish stone is increased and that of the flint diminished as follows:

Blue clay....	10	25	29	45	28.5
China clay...	15	12.5	14	15	....
Flint	20	12.5	..	..	....
Cornish stone	55	50	57	40	71.5

The greater the amount of china clay the whiter the body; with ball clay alone it is yellowish.

The chemical composition of fine stoneware bodies is approximately: Silica, 70 to 75%; alumina, 20 to 25%; iron oxide, traces; lime, 0.5 to 1%; alkalies, 3 to 5%.

Heavy spar (barium sulphate) is sometimes added in large proportion (as much as 50%), the amount of Cornish stone then being reduced.

In coloring the body, 0.5 to 1% of cobalt oxide gives blue, the same proportion of chromium oxide gives green, 7 to 8% of a mixture of iron oxide and manganese oxide makes brown, etc. For basaltic black, the Cornish stone is replaced by a large proportion of red ochre and manganese oxide.

Fine stoneware is frequently dull. Sometimes the surface is vitrified by covering the inside of the saggers with a coating composed of sea salt, saltpeter and white lead. The lead volatilizes, probably in the form of a chloride, and glazes the surface of the ware.

The glazes are usually alkaline, boracic or plumbiferous, like those of feldspathic faience; sometimes the lead oxide and a part of the Cornish stone are replaced by barium sulphate.

614—STONEWARE FOR FOOD AND CHEMICAL PRODUCTS.—This class includes a line of ewers, pots, crucibles, etc., mostly known as "common" stoneware. The body employed is usually a fairly pure vitrifiable clay, which does not need to be washed. It is carefully prepared and made mostly on the wheel. Some pieces, because of their complex shape, are made in a mold. Ordinarily this species of stoneware is rough or covered with a salt or slip glaze when it is desired to make the pieces absolutely impermeable. The glaze is usually intended to develop a brown; it must melt at the temperature which suffices to burn the body. The salt glaze is sometimes replaced by a cheap glaze, applied (1) by dipping, (2) with a brush, or (3) by dusting on the unburned body. These stonewares are now generally burned in round down-draft kilns.

615—STONEWARE GLAZING.—Stoneware articles are usually covered with a glaze. The glazes are made of ingredients which, when heated to the burning temperature of the wares, will fuse and attach permanently to the surface of the ware. The term glazing means literally the formation of a thin surface layer of glass for the purpose of decoration or protection of the ware on which it is placed. In order to serve either or both of these purposes, the glaze must run evenly when melted and neither craze nor shiver after the ware comes from the kiln. Glazes must be uniform in composition and, on rough grades of stoneware, fuse at a fairly low temperature. Where color is to be imparted by means of glaze, the coloring matter must readily and uniformly be absorbed by the glaze ingredients in fusion. There are three kinds of stoneware glazes. (See Salt glazing; Slip glazing; also Bristol glaze.)

STONEWARE PAVING TILE, see Tile, paving.

STONEWARE PIPE, see Sewer pipe.

616—STONEWARE, VASES, STATUES, AND OTHER DECORATIVE OBJECTS.—For these articles, which are rather expensive, bodies of different colors can be employed, and they must be saggered with great care to allow the use of vitrifiable clays without bad effects. The advantage of this class of stoneware, as compared with porcelain or even calcareous or feldspathic faience, is the plasticity of the body which allows it to be modeled by hand without employing molds, and thereby makes possible the creation of original works of art that possess, when burned, the same qualities of resistance and indestructibility as stone or bronze, without requiring any retouching, or the troublesome working inevitably associated with sculpture. The close grain of the body, as well as its color, also gives a very agreeable appearance, and when glazes are employed, they blend exceedingly well with the colored background of the body. All kinds of glazes and all methods of decoration can be employed, altho gilding does not yield as fine results as it does with porcelain.

STORAGE BATTERY, see Battery, storage.

617—STORAGE BIN.—Storage bins for coal, clay, etc., are a necessity if continuous full operation is desired. Coal unloading systems usually provide a bin for two or three cars and if more than this is carried in stock it is dumped from a trestle or unloaded in the open, often on the ground without paving. A better system is to build concrete walls to form a bin so that water can be kept on the coal. If this is done there is no chance of spontaneous combustion. A crane is very useful in handling coal under these conditions. At any rate a paving or floor of some kind ought to be put under every storage of coal, as it will pay for itself in a very short time.

Storage bins for clay are also of prime importance. In some parts of a plant it is good practice to have duplicate equipment, but that is very expensive with the pit and haulage system. Breakdowns are sure to occur whether the material is dug in an open pit or in a mine. In the former case, also, the weather conditions have an effect on the output. A storage of clay, therefore, under cover at the plant is a necessity. This can be arranged so that it can be fed to the pan, roller or other preparing machine automatically or with the expenditure of little labor.

There should be another storage bin between the preparing machine, and the brick or other finishing machine. This is to provide a uniform feed to the finishing machine, if the preparing machine breaks down for a short time. In storing damp ground clay or any material that might freeze to the side walls of the bin, it is good practice to have a space between the inner and outer walls of the bin and to have steam pipes at intervals in this space.

All bins should have conveyors of some kind in the bottom. There are several types of feeders on the market that will empty a bin automatically, and if one of these is not used a belt conveyor with removable boards on top, which is fed by hand is very satisfactory. These boards should be about six inches wide and as long as the conveyor and frame is wide. They should be placed at right angles to the conveyor. (See also Feeder and mixer, clay; Conveyor, belt; and Trestle.)

MANUFACTURERS (see catalog section):
Link-Belt Company.
Weller Manufacturing Co.

618—STOVEROOM, AUTOMATIC.—Automatic storerooms are one of the latest improvements in pottery manufacture. They are really dryers that dry the most intricate shape without loss. This is done by control of the heat and moisture surrounding the ware to be dried. The ordinary dryers do very well for the plainer shapes made of good tough clay, but anything made of tender clay or of odd shape requires special treatment. The principle of this improved drying system is to have every particle of clay ware of the same high temperature, before any moisture is allowed to leave it. This means that the center of the piece will dry as quickly as the outside, whenever the moisture is allowed to evaporate. As a result no drying strains are set up in the ware and uniform, almost perfect ware is obtained. They are used principally in the manufacture of pottery and porcelain. (See also Dryer, humidity.)

MANUFACTURER (see catalog section):
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

MANUFACTURERS' ANNOUNCEMENTS:
Philadelphia Drying Machinery Co., 3351 Stokley St., Philadelphia, Pa. Automatic Stove Rooms built in many sizes to suit varying production requirements. Steel construction, insulated with air-cell asbestos. Recirculation of heated air alternately across steam coils and over the ware, by means of steel-blade disc fans. Automatic temperature and humidity control attached if required. Gives quick, economical production.

STRETCHER, BELT, see Belt stretcher and tightener.

619—STRIPPING.—The term stripping signifies the amount of clay, dirt, stone or other material which must be removed in order to be able to dig or work the deposit desired. Surface clay yards often strip only the grass roots. Plants using shale sometimes strip as much as 20 or 30 feet, and plants using fire clay which cannot be mined economically strip as much at times. In almost every case stripping represents an unproductive expense and therefore the thickness of the stripping and the thickness of the deposit which is uncovered have a direct bearing on whether or not it is profitable to do the stripping. Stripping is done by power shovels, drag-line scrapers, aerial tramways, etc. There is also a method called hydraulic stripping. This consists in forcing a stream of water at high pressure onto the stripping. The result is a muddy rivulet which carries with it all of the stripping except possibly the very large stones. This method is very good and economical where the proper conditions exist, and the resultant mass can be run into a pit of some kind that is lower than the clay deposit. Drag-line scrapers, power shovels, and aerial tramways can load the stripping which they dig, into cars to be hauled to a distant point and dumped, or they can dump it close to the place where it is dug. Power shovels, of course, cannot dump any further than their booms will reach, but drag-line scrapers and aerial tramways can dump as far as their cables will allow. (See also Shovel, power; Aerial tramway; Digging machinery, and Excavator, drag-line.)

MANUFACTURER OF EQUIPMENT (see catalog section):
Green, L. P.

620—STRONTIUM OXIDE.—A fluxing ingredient used in porcelain bodies, but not frequently because of its high cost. It gives a good white to the body, toughness, and a very small tendency to blister.

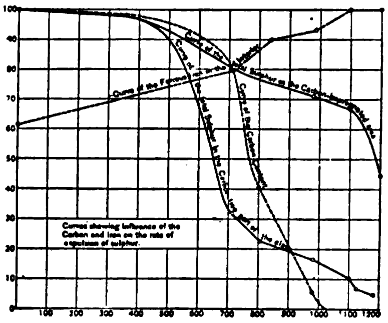
SUCTION CONVEYOR, see Conveyor, suction.

621—SULPHUR.—The amount of sulphur found in different clays varies from a mere trace to an appreciable quantity, and in the latter case may cause serious trouble. For this reason, the best authorities recommend that its quantity in any clay should always be determined by chemical analysis. Sulphur may be present in clay as: (1) sulphate, such as gypsum ($CaSO_4 \cdot 2H_2O$), epsomite ($MgSO_4 \cdot 7H_2O$), or melanterite ($FeSO_4 \cdot 7H_2O$); or (2) sulphide, as pyrite (FeS_2), or marcasite (FeS). Orton and Staley (see Third Report of Committee on Technical Investigation, Nat. Brick Mfrs. Ass'n, Indianapolis, 1908) conducted a series of experiments on a Columbus black shale, running high in carbon, ferrous iron and sulphur, and adopted a series of conclusions enumerating the action of both sulphates and sulphites in relation to the burning of clay ware, and in their opinion the proper way to avoid the effects of sulphur in vitrifying clay bodies is to apply a deliberate and complete oxidation treatment while the clay remains porous. This will rid the clay of the greater part of the sulphur, and will prevent sudden or premature slagging of the clay by ferrous oxide, if it is true that ferrous oxide has such a tendency, and will thus avoid, as far as possible, the conditions which favor swelling. Clays which still give trouble from swelling after this treatment must be regarded as bad clays.

622—SULPHUR, REACTIONS INVOLVED IN EXPULSION OF.—According to Ries (see Clays: Occurrences, Properties, and Uses, 1908 ed.), these reactions may be expressed briefly as follows, the simpler and most probable ones being given:

Pyrite heated to 400 deg. C. (750 deg. F.) gives $FeS_2 + heat = FeS + S$.

The S in the air catches fire and burns to SO_2 or SO_3, but if liberated in a clay soft and spongy by heat it may attack FeO, CaO or MgO. However, most of it probably escapes.



Curves Showing Influence of the Carbon and Iron on the Rate of Expulsion of Sulphur. (From Ries After Orton and Staley.)

FeS exposed to oxidizing conditions might oxidize to ferrous sulphate, but further heating to 550-650 deg. C. breaks it up, leaving FeO, the latter in an oxidizing atmosphere changing to Fe_2O_3.

Calcium sulphate also breaks down, but at higher temperatures than ferrous sulphate and less completely. The action of carbon in restraining the liberation of sulphur is explained as follows by Orton (see Trans. Amer. Ceram. Soc., V., p. 400):

$$FeCO_3 + 425 \text{ deg. C.} = FeO + CO_2.$$

If no free sulphur is liberated in the immediate vicinity

$$FeO + C + S = FeS + CO.$$

This ferrous sulphide cannot be broken up by heat alone, but only by roasting in air or interaction with silicic acid at high temperatures, for, as noted by Seger (Collected Writings, Translation of, II, p. 646, 1902), silicic acid at high temperatures has the power of displacing all other common acids, and combining with their bases to form silicates. It thus has the power to replace sulphuric acid, and the sulphur of sulphides. Seger found that a bisilicate glass mixture, saturated with sulphates, showed 4% sulphuric acid, while the same glass with one or more molecule of silica added and melted at the same temperature and under the same conditions contained but 2% sulphuric acid. Now, in raising the temperature of burning, the fusing matrix of a clay becomes more siliceous, resulting in the expulsion of sulphur.

The diagram above shows the rate of expulsion from Columbus shale tested by Orton and Staley (see also Sulphur).

623—SUPERHEATER, STEAM.—A superheater is an attachment used to heat steam above the temperature due to its pressure. Ordinary or saturated steam is the steam which comes out of the boiler. It contains a certain amount of moisture. If superheated steam is desired, the steam is led thru a series of pipe coils in the upper part of the boiler setting, where the heat of the gases of combustion reheat or "superheat" the steam. This series of coils is called the superheater. By this process the steam is perfectly dried, and the usual difficulties found with condensation, etc., are removed. Several other advantages are also secured. When a superheater is installed and the pipe line protected by a good pipe covering, a steam trap or steam separator is not needed.

624—SUPPLIES, FOR BUILDING CONSTRUCTION.—It is the height of inconsistency for a manufacturer of fireproof materials to build his plant of combustible materials; consequently, only brick and hollow tile should be considered for the outside walls of plant buildings. Concrete composed of cement, gravel and sand forms the best foundations. Lumber is suited to the posts, floors and roof. The roof can be covered with a prepared paper, gravel, tin sheet, asbestos shingles, or what is best of all, roofing tile. These can be bought as shingles or in the fancier shapes. For mortar in the walls of the building or the dryer, lime, sand and cement are necessary. The floors are often made of concrete instead of lumber especially around the machines, and hollow tile form a very good foundation for concrete floors reducing the amount of concrete necessary. In the better class of buildings the lumber for posts, floors and roofs is replaced by posts of steel, concrete, brick or hollow tile. The floors are made of steel beams supporting arches of brick, concrete or hollow tile. The roofs also are made of steel supporting concrete or hollow tile. Gypsum made into blocks is also used for the roofing. The concrete in foundations, floors, posts and roofs is frequently reinforced with iron rods, expanded metal or heavy wire. Felt and paper form good insulation for walls and roof. (See also Concrete; Foundation; and Galvanized iron.)

SURFACE PIMPLING OF SALT GLAZED SEWER PIPE, see Salt glazed sewer pipe, surface pimpling of.

625—SWITCH, ELECTRIC.—In using electric current two types of switches are in common use, the first being the ordinary type of knife switch where a plate of copper is pushed between two other pieces of copper to make the contact. In some cases the switch consists of two knives joined by an insulated handle. This is the ordinary type of open switch. For alternating current and in some cases for direct current an enclosed switch is used. The best type of this switch is made so that the door of the cabinet in which the switch is located is locked closed when the current is on. In all types of enclosed switch a handle to operate the switch is placed on the outside of a box and the switch on the inside.

MANUFACTURER (see catalog section):
International Clay Machinery Co.

SWITCH PLUG, FUSIBLE, see Fuse and fuse plug, switch.

SWITCHES, RAIL, see Frogs, rails and switches.

Many Additional Features

are in preparation for next year. In the meantime send us your criticisms and ideas, so that the book will be better and larger—

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626 — TAKE-UP, BELT.—All belt conveyors and elevators must be taut in order to reduce the trouble caused by a slipping belt. To accomplish this tautness one of the pulleys over which the conveyor or elevator belt operates is mounted on a shaft having boxes movable longitudinally with the belt. These boxes are controlled by long threaded bolts. The belt is tightened by screwing on the bolts until the proper tautness is obtained. When a belt is cut the take-ups are loosened to the extreme, so that as much tightening as possible can be accomplished without recutting. Take-ups are usually 12 or 18 inches in length, and of course this allows for almost twice that stretch in the belt. Almost all take-ups are arranged so that the belt can be tightened while operating and in some cases the two bolts are connected by a chain or by gearing, so that tightening one bolt tightens the other an equal amount. In other cases the tendency of a belt to run to one side can be corrected by tightening one of the bolts.

MANUFACTURERS (see catalog section):

Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Link-Belt Company.
Robinson, Frank H.
Toronto Foundry & Machine Co.
Weller Manufacturing Co.

627—TALC.—Also known as magnesium silicate [$H_2Mg_3 (SiO_3)_4$] and steatite. In a finely ground condition, talc is very white in color. It is used in the manufacture of porcelains and is good for producing toughness, translucency, promoting vitrification, and aiding a body in resisting sudden changes in temperature. Barringer stated that a body containing talc is more heat resistant than porcelain and much better as an electric insulator. (See also Electrical porcelain, all items.)

628—TANK AND TANK TOWER.—Tanks are used for storage of water, and usually they are placed on a tower, in order to give ample pressure at every point. Water is a very necessary item in the manufacture of clay products, as large quantities are used in preparing the clay as well as at the boiler room. A tank located on a tower is also of great assistance in time of fire, no matter how small the fire may be. Tanks are made either of wood staves, bound by iron hoops, or of sheet steel.

MANUFACTURER (see catalog section):
Caldwell Co., W. E.

TELEPHONE—PRIVATE EXCHANGE, see Signalling system or calling device, interdepartmental.

628A—TEMPERATURE ABSOLUTE.—The temperature figured from a point called absolute zero. This point is arrived at by the laws of Boyle and Charles that the volume of any gas under constant pressure increases in proportion to its temperature above this absolute zero. This point is found to be 273 deg. below zero or freezing point on the Centigrade scale, and 491 deg. below freezing or 459 below zero on the Fahrenheit scale. Therefore let A=absolute temperature; let C=deg. C.; let F=deg. F.

Then $A=C+273$
$A=F+459$

TEMPERATURE REGULATOR, see Regulator, temperature.

629 — TENSILE STRENGTH.—This property is estimated on the amount of resistance an air-dried clay will offer to rupture or being pulled apart. Tensile strength is an important property. It has considerable bearing on the problems of handling, molding and drying clay ware. High tensile strength enables the clay to safely withstand the shocks and strains of rough handling. It also permits the clay to carry a large percentage of flint or feldspar, grog, and other non-plastic materials. High tensile strength and high plasticity are often twin properties in a clay, but the former opinion that high tensile strength and plasticity are closely related has been largely discarded, since it is known that a clay low in tensile strength may be highly plastic, and a highly plastic clay may have but litle tensile strength.

630—TENSILE-STRENGTH TESTING MACHINE.—A form of scale equipped with clips which grip the briquette at either end, the arrangement being such that when pressure is exerted the amount of stress necessary to rupture or pull the briquette apart is registered in pounds pressure.

631—TERRA COTTA.—A name given to a clay product which is usually glazed and often highly decorated. In recent years terra cotta manufacturers have produced effects that closely approximate the appearance of different kinds of building stones, and in addition, the decorative character of the designs employed have improved to such an extent, and cover such a wide range of requirements that few large modern buildings are erected without the use of a considerable quantity of terra cotta. Terra cotta very seldom is used for load-bearing purposes, and is usually anchored to the steel skeleton of a building. Its chief use is as a facing or decorative material.

TERRA COTTA DRYER, see Dryer, terra cotta.

632—TERRA COTTA LUMBER.—This is a form of hollow ware fireproofing, which may contain one or more interior cross-webs or partitions to give it strength. Terra cotta lumber is made by being molded thru a stiff-mud die. It is soft and porous, due to the addition of a large percentage of sawdust to the clay. The sawdust burns off in the kiln, leaving the material so soft and porous that nails can be driven into it. It is used principally for partitions, both in fireproof and non-fireproof buildings.

MANUFACTURER OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.

633—TERRA COTTA, MANUFACTURE OF.—The clay used in making terra cotta is often first exposed to the weather, usually to facilitate disintegration, and then run thru a dry pan, following which the ground materials are sent to the wet pan for tempering; they may then be still further mixed and masticated by a pug-mill, either of the vertical or horizontal type. Then, as the bar of clay is issued from the pug-mill, it is cut into lumps which are piled up and kept well covered until ready for use.

Terra cotta is formed by hand, either by means of plaster molds or by modeling. Simple forms are wrought in plaster molds, but every terra cotta plant has its staff of skilled artisans for the free-hand modeling of intricate undercut designs, etc.

In molding terra cotta it is customary to make a plaster mold inside of which the clay can be cast. Small and simple articles may thus be cast in one piece, while the bigger articles or special shapes are formed in a number of pieces which are joined together as they are set in the building. In filling a plaster mold the plastic clay is forced into all the crevices and corners and spread to a depth of about 1½ ins. over the entire inner surface of the mold, after which the sides are connected by clay wall partitions to strengthen the piece. The model is then set aside for several hours, giving the clay an opportunity to shrink sufficiently to allow of its being removed from the plaster form without danger of breaking. Any rough or uneven edges are usually trimmed out with a knife.

Terra cotta ware is usually dried on steam-heated floors, and, in the case of large pieces, necessarily involves a slow and careful method of drying and handling. (For details, see Dryer, terra cotta.) Having been air-dried, the green ware is sent to the spraying-room, where the slip which is to form the surface coating is sprayed on; this slip covers the entire surface in a thin layer, and is also to a certain extent absorbed by the body of the ware. It is commonly a mixture of kaolin, ball clay, quartz, and feldspar (or other fluxes), to which the required coloring agencies have been added; thus it both forms an impervious layer on the surface of the ware and simultaneously produces the desired color effect. It ofttimes is of such composition as to burn to a dull enamel. The demand for matt-glazed or semi-dull glazed terra cotta is steadily increasing in this country, but full-glazed terra cotta is rarely used.

Terra cotta is generally burned in circular down-draft kilns of the muffle type, ranging in diameter from 15 to 25 ft. The different pieces of ware are set in the kiln surrounded by a framework of tiles and pipes of fire clay, so that, during burning, no object has to support any weight except its own. The shrinkage during drying and burning may average about 8%. The ware is never burned to vitrification. Some manufacturers burn as low as Cone 02; but the average burning temperature ranges between Cones 6 and 8.

MANUFACTURER OF EQUIPMENT (see catalog section):
American Dressler Tunnel Kilns, Inc.
Hadfield-Penfield Steel Co.

634—TEST FURNACE.—A test furnace is a small kiln that is used to obtain quick results concerning the quality of clay products. Test furnaces are used mostly by the manufacturers of refractories, in order to determine the heat resistant qualities of certain raw clay or manufactured ware. They are usually fired by fuel oil which is forced into the furnace by air under pressure. A temperature of 3,300 deg. F. can be reached in the space of a few hours. In testing structural clay products, a small commercial kiln is usually employed which reproduces actual conditions better. A test furnace for the refractory industry is usually built of iron with a brick lining. These furnaces can also be used to reproduce the actual conditions under which refractories are used. For instance, the spalling effect due to repeated changes in temperature, is reproduced by heating brick to the temperature desired and then plunging them into cold water while hot. This can be carried on with a number of brick at the same time, and repeated heatings and coolings made. The percentage of loss gives a good indication of the comparative loss from spalling.

MANUFACTURER (see catalog section):
Stevenson Co.

TESTING SIEVE, see Sieve, testing.

635—TEXTURE.—This term refers to the size of grain or fineness of a clay. Texture exerts an important influence on the physical properties, such as plasticity, shrinkage, porosity, fusibility, etc. Numerous clays have sand grains visible to the naked eye, but the bulk of clay particles are of a microscopic size, and therefore too small to separate them with sieves. For practical purposes, however, it is common to test the texture of a clay by determining the per cent. of any sample that will pass thru a sieve of 100 to 150 meshes to the inch. If it is necessary to measure the size of all the grains found in a certain clay, some more delicate method of separation is required.

Texture is also referred to in classifying the type of surface of a face brick. For instance, there are rough textured face brick of different textures produced according to various methods, such as stretching a wire across the mouth of the brick die, scratching the surface with nail points, stamping, or otherwise marking the face of the column.

636—THERMOMETER.—A thermometer is an instrument for indicating or recording the temperature of any material or location. In most thermometers the expansion or contraction of a liquid or gas is utilized. The common form consists of a glass tube of capillary bore, terminating in a bulb, and containing mercury or alcohol, which indicates the degree of heat to which it is exposed by the amount of space it occupies, as shown by the reading at the top of the liquid column on a graduated scale. This is called an indicating thermometer. A recording thermometer is one which is equipped with an arm terminating in a pen which is supplied with ink. The arm moves back and forth over a limited space as the temperature varies. At the same time, a clockwork mechanism rotates a graduated sheet of paper beneath the pen at uniform speed. As the paper is graduated for 24 hours it records the temperature for that time. Recording thermometers are suited especially to record the temperature of dryers, mangles, automatic storerooms, hot floors, etc.

Generally, thermometers are used for recording lower temperatures, while a pyrometer (see this item) is used for such temperatures as are met with in burning clay wares.

MANUFACTURERS (see catalog section):
Brown Instrument Co.
Engelhard, Chas., Inc.
Rodgers, L. E., Engineering Co.

THERMOSTAT, see Dryer, humidity.

637—THROWING.—This is the oldest method of forming pottery. The use of the turning or revolving disc dates from at least 3000 B. C. The Greeks, who employed a boy at the wheel, claim credit for the invention; the Chinese, however, claim the process was familiar to their potters 7000 B. C. The early Italians employed a string to give power; later, like the French, they used a large table underneath the disc, the table being kicked around by the thrower while he manipulated the clay with his hands. In Staffordshire, Eng., the wheel was formerly driven by a large flywheel turned by hand, which by means of a long rope moved the upright spindle on which the thrower's disc was fixed. The wheel is now usually driven by steam power and the speed regulated by two cones, one of which is inverted.

The process of throwing is the application of the principle of turning to a plastic material. Generally, the wheel consists of a horizontal disc rigidly attached to the top of a vertical spindle, to which a rotary motion can be imparted. A piece of clay, thrown above the disc, is raised to the shape of a cone by the potter's fingers and again depressed, this operation sometimes being repeated two or three times to solidify the clay mass. Care is taken to remove any slurry that appears at the top of the cone, since slurry tends to produce cracking of the ware. The thrower then begins to shape the article, first by hollowing out the clay lump with his fingers, then by quickly drawing the outer edges to the required height, after which a tool or profile, made of wood or steel, is employed to give the necessary shape; the thrower's fingers shape the outside of the piece. The dimensions of the article are fixed by means of gages placed in a rigid holder arranged conveniently near the disc.

In making large pieces, and often in the throwing of china, the thrower shapes the clay inside of a plaster mold. If the shape required is round, as with jugs or vases, all kinds of ware can be produced on the thrower's wheel. Sometimes, very large pieces are thrown in two or three parts and later fastened together.

Wreathing and cracking are the principal faults resulting from throwing. Wreathing may be produced by irregular pressure on the clay during manipulation, or by not carefully running up the height of the article at a rate commensurate with the speed of the disc. Cracking is produced by indifferent manipulation of the clay, the thrower not making it sufficiently solid or leaving slurry inside the piece.

After being formed, the object is separated from the disc by running a thin wire under it.

TIGHTENER, BELT, see Belt stretcher and tightener.

638—TILE MACHINERY, ROOFING.—In the manufacture of roofing tile, the thoro preparation of the clay to make it perfectly homogeneous is very necessary. If this is not done the drying and burning strains which result cause a very heavy loss, entailing sometimes the success of the plant. Usually a small auger machine is used which makes a thin ribbon of clay, of the desired thickness and width. This is cut into the proper length, and pressed into the shape desired. The press has two or more molds which either revolve or slide back and forth. At any rate they are arranged to dump the finished tile onto pallets for drying, as they cannot be handled by hand.

MANUFACTURERS (see catalog section):
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Mueller Machine Co., Inc.

639—TILE, PAVING.—These are used either for paving or walling. In the first case, they are either of terra cotta or stoneware; in the second case, they are of glazed terra cotta, faience, stoneware, or porcelain. Paving tiles are usually square or hexagonal; the length of each side is from 4 to 12 ins., the average being 6 ins. The thickness depends on the other dimensions, on the method of making and on the nature of the body, and varies from ¼ in. to 3 ins. The body used for paving tiles is the same as that for making other brick and tile, and the methods of molding by hand or producing by machinery are identical.

MANUFACTURER OF EQUIPMENT (see catalog section):
Hadfield-Penfield Steel Co.

640—TILE, ROOFING.—There are three general types of roofing tile: (1) shingle or flat tile, (2) Spanish or normal tile, and (3) interlocking tile. The quality of roofing tile is determined by two standards: (1) artistic, as to design and color, and (2) practical durability, strength and weight.

Shingle or flat tile are simply designed. The average shingle is about 15 ins. by ⅜ to ½ in. by 6 ins. Holes are punched thru the tile to hold it to the roof. Shingle or flat tile generally are designed with vertical ridges and valleys to present a neat appearance. Spanish tile are shaped like a flattened S. Interlocking tile are rectangular in outline, generally 9 ins. wide by 16 ins. long, with the outer surface usually more or less broken by vertical lines or corrugations.

The distribution of weight in tile is very important. Shingle tile ⅜ in. thick weigh about 1,100 lbs. per 10-ft. square; the ½-in. thick size weighs about 1,200 lbs. per square. Interlocking shingle tile, ½ in. thick, weigh about 800-900 lbs. per 10-ft. square. Spanish interlocking tile weigh about the same.

In selecting clay for the manufacture of roofing tile, the qualifications to be considered carefully are, plasticity, strength, shrinkage, burning behavior, fusibility, color, hardness, and porosity. The strength which a clay develops in drying is very important. Tile ware for the most part is a thin cross section and unless it is fairly strong large losses will occur in handling when the ware is being set in the kiln, especially if no kiln support is provided. Consequently, the clay should be able to resist the crushing strain of superimposed tile and such mode of setting as is most economical. A test to determine the tensile or transverse strength of the clay is advisable.

TIME RECORDER, see Clock; Clock, watchman's, and Recorder, time and operation.

641—TIRE, AUTOMOBILE AND MOTOR TRUCK.—Tires for auto trucks are of two general types, pneumatic, in which an inner tube filled with compressed air is enclosed in a casing, and solid, in which the tire is composed of layers of fabric and rubber. Solid tires may be of one piece as when they form the entire perimeter of the wheel or they may be formed of a number of pads or layers of fabric and rubber, fastened to the perimeter of the wheel. The latter type is especially suited for heavy loads and where the road is soft. The wear on auto truck tires around a clay products plant is a large item and care must be exercised in deciding which type to use and also in keeping cinders, iron, nails, boards, wire, etc., out of the roadway to be traversed by the truck. Some wheels are equipped with a flange or other attachment to prevent the truck getting stuck in mud, etc. This attachment is mentioned here because it helps to prolong the life of the tire. (See also Wheel, automobile and motor truck.)

MANUFACTURER (see catalog section):
Goodyear Tire & Rubber Co.

642—TIRE, INDUSTRIAL TRUCK.—Tires for industrial trucks are made on the same lines as those for auto trucks. (See Tire, automobile and motor truck.) Solid tires of one piece, entirely encircling the rim of the wheel, are the ones most used on industrial trucks. For handling burned ware the tires are often made of iron.

MANUFACTURER (see catalog section):
Goodyear Tire & Rubber Co.

643—TITANIUM.—An element (T.) contained in several minerals, among them rutile and ilmenite, which are found in clays on close analysis. In the ordinary chemical analysis, titanium is usually included with the alumina.

644—TOOL STEEL.—Tool steel is a steel used for making tools to cut or machine other metals. It is high in carbon content, as that property is necessary to enable it to be hardened. Tool steel is made in many various commercial bars, etc., so that it can be made into almost any type of tool desired. Heating, annealing and tempering tool steel are particular operations, and require precaution and experience. Heating the tool too high will result in "burning" the steel and this causes a change in the structure which renders it unfit for tools. Annealing, or the cooling of the steel after being heated to the proper temperature, must be accomplished as slowly as possible. The slower the better. Tempering consists in hardening the steel more than necessary and then toughening it by slow heating and gradual softening until it is just right for work. Tool steel is used for lathe tools, cold chisels, hot chisels, saws, drills, shaper and planer tools, etc. There are several grades of tool steel containing varying amounts of carbon. It is important that the proper steel be used for each class of work, because a high carbon content will produce a harder tool than a low carbon content when both are given the proper treatment. A tool does not give good service when it is either too soft or too hard, and care must be used in specifying tool steel for this reason.

645—TOURMALINE.—A mineral sometimes found in kaolins derived from pegmatites. Large crystals of it are often discovered in the kaolin of Henry County, Va.

TOWER, TANK, see Tank and tank tower.

TRACK, RAILWAY, see Frogs, rails and switches.

646—TRACTOR AND TRACTION ENGINE.—A traction engine is generally considered practically the same as a locomotive, having a boiler and steam engine, but moving on the ground without the aid of a track. A tractor as known today is practically the same but has no boiler and derives its power from either electric storage batteries or an internal combustion engine. Industrial trucks and tractors are almost identical as used in clay products plants. Where clay must be hauled a mile or more, tractors of the type used on road construction or on farms are found to be suitable. (See also Tractor, Industrial, storage battery; and several items under Truck.)

647—TRACTOR, INDUSTRIAL, STORAGE BATTERY.—Two general types of storage battery tractors are in wide use in the clay products field.

In one type, the driving system is similar to that of the industrial carrying truck. In this type, the operator sits on a spring seat over the battery box carried above the truck frame proper, and controls the forward and reverse movements of the tractor, in all speeds, with his left hand. The steering is controlled by a lever operated with his right hand. The left foot generally controls the brake pedal, and the right foot the circuit breaker pedal. This type of tractor is virtually a miniature locomotive and may be used on rails when equipped with flanged wheels. It has a short wheel base and consequent turning basis. It is well adapted to handling long trains of flatcars, trucks, and similar vehicles.

The other type of storage battery tractor is best adapted to pushing or pulling single trailers. In this type the operator stands on a small, separate platform at one end of the truck, and at the opposite end is located an automatic or non-automatic coupler. The low section of the truck platform is thus free to carry a portion of the material to be hauled.

Wide variations in design and capacity enable the purchaser to choose the style and size of tractor best suited to the conditions.

TRAILER, TRUCK, see Truck trailer.

TRAMWAY, AERIAL, see Aerial tramway.

648—TRANSFER CAR.—In using dryer cars, it is necessary to be able to take the loaded cars from any track on which they are loaded, and place them into any of the dryers. Again it is necessary to take the cars from any of the dryers and place them on the track or tracks going into the kilns. This is done by means of transfer cars, which are usually of broad gage, and capable of carrying one, two, or three dryer cars at a time. The smaller plants usually use labor to push these transfer cars, but the larger plants use power transfer cars, and electricity is very suitable for this purpose.

MANUFACTURERS (see catalog section):

Eagle Iron Works.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.

649—TRANSFORMER.—A transformer is a machine for changing electrical current or energy from one form into that of another form. In public utility sub-stations rotary transformers or converters are very frequently found, but the static transformers are the type usually employed on a clay products plant. When current is purchased from a public utility, it is generally transmitted at as high voltage as possible, because of the smaller loss, and the smaller wire required. High voltage is dangerous in and around a plant and a transformer is used to reduce the voltage to a suitable amount. This type of transformer usually consists of a box fastened to a post. On the inside of the box the wire of the current from the power station and the wire of the plant current are wound around an iron core in such a way that the current in the plant wire is of the desired voltage. A transformer is usually filled with oil to equalize the temperature in all parts. Transformers are subject to becoming heated. When the voltage in the plant current is lower than in the "primary," the transformer is called a "step-down" transformer. Otherwise it is a "step-up" transformer.

650—TRAP.—Traps are attachments for draining water out of steam lines or heating systems. The coils used for heating a building or for a dryer must have a trap of some kind to remove the water of condensation. When live steam is the heating medium a steam trap (see special item under that title) is used. When exhaust steam is used a vacuum pump (see special item under that title) is often used, and a vacuum trap is also very satisfactory. There are also tilting traps that will take care of condensation from either live or exhaust steam, and some of these are built to return the water into the boiler at practically the same temperature that it is condensed at. This, of course, may be more than 212 deg. on account of the pressure. These return tilting traps have been known to handle water of 250 deg., something that a pump cannot do.

TRAY, see Pallet and tray.

TREAD-PLATE, see Pan, dry.

651—TRESTLE.—A trestle consists of an overhead railway track supported by a framework of timbers or steel. Ofttimes, storage bins are built into the supporting framework directly under the track; in other cases, all space under the track is left vacant for open-air storage. By means of trestles and the use of bottom-dump cars, clay, shale, coal, etc., may be handled and stored with great facility. Where bins are used, they may be made to serve as hoppers, by means of which trucks, wagons and carts can be loaded in a very short time at a minimum of expense. In addition to being used to create a large storage space for coal, raw materials, etc., trestlework may be used to support car tracks running from the pit where they cross a creek or ravine, or to elevate them above dangerous railroad crossings, etc.

TRIPPER, AUTOMATIC, see Conveyor, automatic trippers for.

TRIPPER, BELT, see Conveyor, automatic tripper for.

TRUCK AND WAGON LOADER AND UNLOADER, see Conveyor, all items but especially portable. For unloading see Truck dump bodies.

TRUCK, AUTOMOBILE, see Automobile truck.

652—TRUCK, CRANE, STORAGE BATTERY.—The industrial crane truck is usually a rigidly built, short, heavy, storage-battery vehicle, equipped with a swinging crane mounted on its forward end. The trucks are built with a short wheelbase, which enables them to be easily turned in a small space, a very essential feature in entering aisles, dodging boxes, machinery, etc., about the plant. The truck is generally equipped with a draw bar for hauling trailer cars and the rapid transferring of large quantities of material. The charging and care of a storage battery is about the same as for an industrial storage battery locomotive. One man controls all movements and operations, both of crane and truck. The capacity of the crane varies with different makes, but it averages about 2,000 lbs.

MANUFACTURER (see catalog section):

Hadfield-Penfield Steel Co.

653—TRUCK DUMP BODIES.—These bodies are made so as to unload their contents quickly and automatically, and generally are of two types. The first has a V-shaped body with the point of the V downwards. On each end of the body a track is built into the truck, in order to guide the body as it turns to dump its load. The dumping is done by pulling a lever which holds the body in its upright position. The weight of the material inside of the body turns it over, because after the catch is opened by the lever the material is really balancing on one point.

Another type of dump body is one that has the rear end fastened to the chassis or frame of the truck, and some mechanical means provided for hoisting the front end. The end gate opens automatically as the body is raised and the material slides out.

Any type of dump body is suited to haul coal, ashes, clay, cinders, shale, rubbish, excavated material, etc. (See also Automobile truck.)

MANUFACTURERS (see catalog section):

American Truck Body Co.
Easton Car & Construction Co.

MANUFACTURERS' ANNOUNCEMENTS:

American Truck Body Co., Inc., Martinsville, Va., manufacture the Fontaine Demountable Truck Body, for hauling brick without any loss from breakage. Let us supply you with these bodies and save any claims for damaged or defective brick. At the same time we can greatly reduce the cost of handling your burnt product. These features are advantageous with any and every class of clay products but especially with high class ware such as face brick, fire brick, etc. One of the big advantages of this body is the demountable feature which enables a truck to do any kind of hauling. The dump body can easily and quickly be replaced by another body that is suited to haul coal, ashes or clay. This enables the owner of a truck to have the efficiency of two trucks with the initial cost and operating expense of only one.

Easton Car & Construction Co., 200 Fulton St., New York, N. Y. Easton Scoop Bodies for Fords and Easton Roll-over Bodies for Fords and all other makes of cars can be furnished in ¾, 1 and 1¼ cubic yard capacities. Bulletins and prices gladly furnished upon request. See our page in the catalog section.

654—TRUCK, HANDPOWER WAREHOUSE, ETC.—Handpower trucks are distinguished from wheelbarrows principally by the fact that a truck usually has a flat bed on which the ware is placed. The large majority of trucks have two wheels while the large majority of wheelbarrows have only one. Most trucks also have springs. Trucks are especially suited for the manufacture of dry pressed brick, because the brick can be handled with more care and less damage. They are also suited to handle brick, drain tile or any output of a stiff-mud machine made from surface clay, that is put into a drying shed direct from the machine. Fire clay shapes are often taken to the kilns on trucks. The various makes are furnished in a variety of sizes, generally about six feet long and two feet wide.

MANUFACTURER (see catalog section):

Toronto Foundry & Machine Co.

655—TRUCK, INDUSTRIAL, ELECTRIC.—The construction of electric industrial or "factory" trucks varies greatly, the chief differences being found in (1) the kind of platform used, whether it is a straight platform or a drop platform, (2) in the location of the storage battery or batteries, (3) in the location of the motor, (4) in the transmission of power, either by worm drive or differential gearing and chain drive, and (5) in capacity.

For ordinary purposes, such as for carrying brick, tile, sewer pipe, etc., a flat platform is mounted on springs on four rubber-tired steel wheels, and provided with a storage battery, ball bearing motor, ball bearing steering head, operating and controlling levers, circuit breaker and brake. The motor and battery may be mounted in any one of several familiar positions, and the power transmitted to one set of wheels only or equally to both sets, according to design. In either case, all operations are controlled by one operator who stands on an extension platform at one end of the truck.

The operation of all makes of industrial electric trucks is so simple that they can be run forward or backward with equal speed and facility and may be operated by unskilled labor. Capacities usually range from ½ ton to 2½ tons. The cost per ton mile for a 1½-ton truck is estimated at about ¾ ct., based on electricity at 7 cts. per k. w. hr. One charge of a 1½-ton truck battery is generally sufficient for hauling a 3,000-lb. load on deck a distance of about 65 miles on level, and will be able to haul this load up a grade of 10% or more. Trucks of other capacities may be operated with similar economy. Flanged wheels, for operating on narrow gage railway tracks are frequently provided. The electric truck can be used to draw one or more light trailers.

656—TRUCK, LIFT OR ELEVATING PLATFORM, HAND AND ELECTRIC POWER.—Elevating or lift trucks are of two general classes, handpower and electric.

In the handpower types, the design is simple and efficient. The truck consists of a flat platform mounted on four wheels. The wheels may be flat tread or rubber-tired for traveling on a fairly smooth floor or platform, or they may be flanged for operating on a narrow-gage railway track. A crank, placed at either end of the car, furnishes the means of elevating. The elevating device usually consists of a sleeve surrounding the axle with an eccentric in the middle and at each end. The eccentrics are turned to the same diameter. Those on the ends of the sleeve run in self-aligning bearings. The center eccentric carries a worm wheel. The operating worms are mounted on a shaft running over the axles and at right angles to them. This worm revolves the eccentric for raising or lowering the car. Numerous modifications of this design are supplied by different manufacturers, however, with corresponding claims for efficiency, ease of operation, etc.

The electric storage battery lift truck is built upon similar lines, except all operations are mechanically controlled, and the ease and speed with which loads up to 4,000 lbs. may be lifted and conveyed from one location in the plant to another make it an especially economical time-saving and labor-saving factor in plants where it is necessary to handle brick, tile, sewer pipe, etc., in large quantities. The economy obtained in the quick dispatch of parts between buildings is further increased, in many instances, by additional production of the departments themselves.

In operating the electric lift truck, the operator stands on an extension platform facing the truck, controlling its speed with the right hand and steering it with the left hand. He drives drop platform of truck under the loaded pallets, trays or platform, pushes the switch which operates the lifting mechanism, and immediately the truck platform raises and exerts a uniform pressure under the loaded truck. The lifting device is generally controlled by an independent motor which automatically stops when end of upward or downward travel is reached. The electric lift truck is mounted on rubber-tired or flanged wheels, as desired.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.

657—TRUCK TRAILER.—Small wagons that are fastened to a tractor or auto truck and pulled by it. They consist either of a frame with four wheels and a body which is generally suited to the particular work to be done, or of the same type of body with only two wheels instead of four as above. In this case the front part of the trailer where the axle for the front wheels ordinarily would be placed is mounted onto the frame of the truck or tractor, and part of the weight carried by the trailer is borne by the rear wheels of the truck or tractor. In clay products manufacture, trailers are used principally in hauling clay from the pit, and in hauling green and burned ware to and from kilns. Trailers in reality are cars that do not operate on a track. See also Car, all items; Truck dump bodies; Ball bearing; Roller bearing. When clay products are delivered by auto truck, trailers can be used to good advantage, because they practically double the load that can be hauled. Trailers also reduce the time necessary to load and unload a truck, thus obtaining more mileage per day. In addition, the use of trailers obviates considerable cost in extra handling of the ware at both the loading and delivery ends of the trip.

TRUCK WHEEL, see Wheel, all items.

657A—TUBE MILL.—This is a cylindrical mill for continuous fine grinding of clay and similar material in a pottery. It is used for material for which there are larger requirements than can be economically ground in a ball mill.

MANUFACTURER (see catalog section):
Stevenson Co.

658—TUBING.—The principal use of tubing around a clay products plant is the tubes for the boilers. These boiler tubes are made of lap-welded charcoal iron. This means that the two edges of the sheet are laid one on top of the other and then welded into a tube. Boiler tubes must be very accurate as they must fit snugly and yet loosely enough thru the holes in the heads. Boiler tubes are made in diameters varying a quarter of an inch from one inch to four inches. The next size is 4½ inches, then five. The sizes vary from that to 21 inches in diameter at one inch apart. All boiler tubes are measured on the outside diameter. Wrought iron and steel pipes are also lap-welded tubes. (See also Rubber tubing.)

659—TURBINE, STEAM.—A steam turbine is a machine by which the energy stored in steam is converted into rotary mechanical energy without the use of a steam engine. The steam is impinged on blades which are built into a wheel or disc mounted on a shaft in such a way that the force of the steam makes the wheel or disc rotate. When properly proportioned a turbine shows greater efficiency than an engine because the resultant motion does not have to be changed from reciprocating into rotary. Large turbines are used for driving generators and alternators, and small turbines are now on the market that are especially suited to drive fans, blowers, boiler feed pumps, circulating pit pumps, etc. These operate at as low as 60-lb. pressure and 1,200 r. p. m. Reduction gears are employed when lower speeds are required or desired.

659A—TURNER, SEWER PIPE.—In making large drain tile and sewer pipe the ware is dried on end and almost always one end dries faster than the other. In order to assist in having all parts dry at the same time and also to reduce the danger of one end cracking due to the large shrinkage, this class of ware is turned during the drying. As soon as the ware is hard, the turner is placed next to the tile and raises it on its pallet. Another pallet is placed under the other end and the turner rolled over so that the tile can be placed on the floor on the second pallet.

MANUFACTURER (see catalog section):
Stevenson Co.

660—TURNING.—This is a process used in making and decorating certain classes of pottery by means of a lathe, which, in many respects, resembles the lathes used for turning wood or metal, as it consists essentially of a horizontal shaft to which motion can be applied. Formerly the shaft was driven by a treadle worked by a woman, but this type has largely been replaced by the steam lathe. The motion in a steam lathe is derived from a disc worked against a pair of cones. The disc is controlled by a lever, by means of which it can be thrown against either cone, thus enabling the workman to give the spindle a backward or forward motion and also to regulate the speed of the lathe to a certain degree.

After the forms are made roughly by a thrower or on a jolly, they are given to the turner, whose duty it is to make them into the exact shape required and to finish the surface of the ware. The forms made by a thrower are too soft to be turned without first being dried, usually about "leather" hard. The form, if a vase, cup, etc., is fastened to a flat disc or chuck, which is attached to the spindle of the lathe by means of a screw. To hold the article in position of the disc its surface is covered with slip and the article is centered on the disc; a tool is then pressed against the clay at the point of contact, which welds the article to the disc. By means of sharp tools the turner then shaves off the superfluous clay, as the article revolves, until the required shape is attained.

The size is determined by means of callipers which have previously been set to the required size of the neck, middle and foot of the article, the height also being measured by a previously set gage. The surface is smoothed and polished by means of a smooth piece of steel pressed against the surface of the ware. The article is then taken from the lathe. If the bottom needs to be turned, the article is reversed and fixed inside a clamp lined with clay, and, when centered, the turner shapes it as before.

By the use of milling tools a great variety of decorative effects can be produced by the turner; the tools are small wheels with impressed or sunken designs on the edge. Fitted into suitable holders, they are pressed against the revolving article and give it the required design.

When the article is removed from the lathe, the rough edges are sponged smooth. If handles are needed, the ware goes to the handler while in a soft condition; otherwise it is immediately dried, preparatory to firing. Cups, mugs, double-egg cups and similar articles are finished by turning. In England, little turning is done in earthenware potteries. In this country, turning is more often employed for fine finishing after the cup or other article is made by the jiggerman.

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

661—TURNTABLE.—Practically any revolving platform or table which operates flush with the ground or floor, the table being designed to carry tracks or rails and turn on a central vertical pivot. The construction is usually such that the center of the table is supported by a center post, which fits into a turned raceway, and by a series of wheels or ball bearings which support the outer rim of the table as it revolves.

Portable turntables are also extensively used in brick kilns. The principle of construction remains practically the same as in the fixed-position types, except the entire turntable is so designed that it can be easily moved on skids, or by other means, to any desired point.

MANUFACTURERS (see catalog section):
Bonnot Co.
Easton Car & Construction Co.
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Steele, J. C. & Sons.

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U

UNDERGLAZE DECORATION, see Decoration, underglaze.

UNLOADER, CAR, TRUCK, AND WAGON, see Conveyor, all items, especially portable; Wagon dump body; Truck dump body; Car unloader.

662—USED EQUIPMENT.—Very frequently a manufacturer desires to use certain equipment for a limited time and does not feel justified in a large outlay of money because he cannot figure a large enough profit or high enough depreciation to pay for the investment for a short space of time. In this kind of a case three avenues are suggested for him; first, sell the equipment to a used equipment dealer when he is thru with it; second, to rent the equipment from this same dealer without spending any money for capital outlay; and thirdly, buy the equipment from this same dealer at a greatly reduced price from the original first cost.

V

VACUUM PUMP, see Pump, vacuum.

663—VACUUM TRAP.—A steam trap will remove the water of condensation from any heating system or steam coils. A vacuum trap will do this and in addition will work on a heating system that operates under a vacuum, and will retain that vacuum at all times. It is a sort of steam trap and vacuum pump combined.

664—VALVE.—A valve is an appliance or mechanism for controlling the passage and flow of a gas or liquid thru a pipe or other conduit. Practically all parts of valves are made of cast iron, cast brass, cast bronze or cast steel. The renewable seats and discs are lined with a composition over the area of greatest wear (see following additional classes).

665 — VALVE, BLOW-OFF. — These are used at the lowest point in the pipe line connected to a boiler, that is, the lowest point after passing the check valve. They are used to blowdown a boiler, i. e., remove the scale and sediment that is bound to accumulate. They are usually of two types, a plug valve in which a casting of the shape of a frustrum of a cone turns inside of another casting. At one point the plug has a hole thru which the scale and sediment mixed with a certain percentage of water is blown by the force of the pressure in the boiler. This hole must be large enough to afford flow at the full capacity of the pipe. The other type is a Y blow-off valve. This is practically the same as a globe valve with the handle and spindle turned at an angle of 45 deg. from the flow instead of at right angles. With this construction the diaphragm does not offer as much friction to the flow as does a globe valve.

Some engineers advise two valves in every blow-off line, so that the first one, or the one nearest the boiler is opened before and closed after the second valve or the one farthest from the boiler. By this arrangement the first or inside valve is never opened or closed while there is any flow of sediment passing, thereby reducing the wear on its disc and seat. The second valve in case more than one boiler is used can be connected to the blow-off pipe that is used for all the boilers.

666—VALVE, ENGINE SLIDE, ROCKER, OR CORLISS.—In steam engines there are two main types of valves for controlling the admission of steam to the cylinder, the slide valve and the rocker or Corliss valve. In the slide valve type the valve, consisting of a metal plate which is reciprocated by an eccentric, travels the same distance for every revolution of the engine. In its travel it successively opens and closes the ports to lead the steam into and out of the cylinder. With this type of valve the speed of the engine is controlled by a governor which regulates the amount of steam entering the valve chest, and the ports spoken of above, which are opened and closed by the slide valve. Practically all steam pump valves, especially of the boiler feed type, are slide valves.

The rocker valve is turned by rods as the engine revolves. There is usually a valve for the inlet and outlet for each end of the cylinder, making four for each engine or each cylinder of a compound engine. In turning, a rocker valve opens and either admits live steam into the cylinder or exhaust steam out of it. The amount of turn or rock is controlled by the speed of the engine, so that in this type the speed of the engine is governed by the point at which the valve closes.

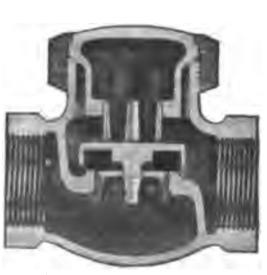
667—VALVE OR GATE, STORAGE-SYSTEM.—In storing coal, sand, etc., in a bin, a valve must be provided for feeding the material out of the bin when it is to be used. This valve or gate may consist of two swinging blades or jaws which operate like a grab-bucket, the two blades being controlled by one lever. Another method consists of placing a piece of heavy sheet steel between guides and using a lever to open or close the valve—i. e., to slide the sheet-steel gate back and forth in the guides as desired.

MANUFACTURERS (see catalog section):

Link-Belt Company.
Weller Manufacturing Co.

668—VALVE, PIPE BASIC TYPES OF.—A gate-valve is one in which the part to control the flow is moved up and down at right angles to the flow. This moving part or gate is of a wedge shape and a face is provided in the main casting of the valve so that when closed the gate makes a perfect cut-off.

A float-valve is one that regulates the level of a liquid within certain limits, so that if the level becomes too low, more liquid will be put into the tank, and if it gets too high the supply will be cut off.

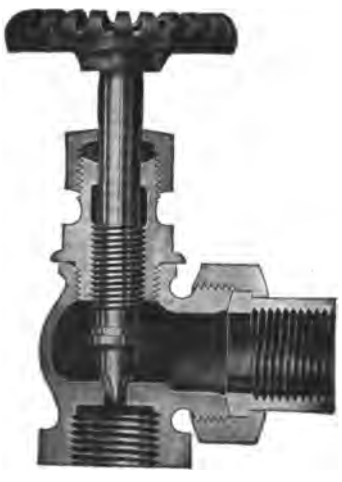


Section of Horizontal Check Valve.

A float-valve is of very good service in a tank for storing water, especially if the tank is overhead or on a tower.

A check-valve is one which automatically closes when the pressure on the side from which the flow comes, is removed. A swinging or sliding disc is provided on the inside of the valve which as stated above works automatically. The main use for a check-valve is in the boiler supply line, so that whenever the pump or injector is shut off the check-valve will automatically close and thereby prevent any water leaking thru the idle pump or injector.

A plug-valve is one in which the flow of liquid or gas is controlled by turning of a machined casting which has the shape of a frustrum of a cone. This plug fits into the main casting which is machined to fit it. A plug-valve is suited to any place where quick opening and closing are advantages, such as on a boiler blow-off.



Section of Angle Needle Valve.

A globe-valve has a ring or diaphragm cast into the inside of the main casting, and the rest of the valve is made so that all of the flow must pass thru this ring when the valve is open. This ring is called the seat. A disc is provided to fit tight against this ring when the valve is closed, and a screw or lever is provided for moving the disc at right angles to the flow.

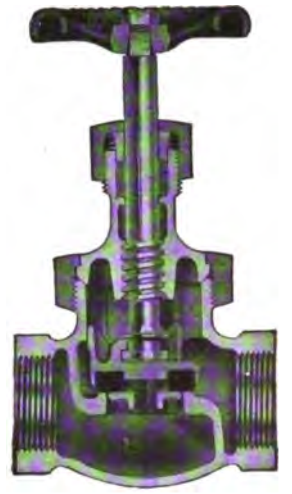
An angle-valve is practically the same as a globe-valve except that it is placed at a point where the pipe makes a right-angled turn, thus replacing an elbow. The movement of the disc is parallel with one pipe and at right angles with the other.

Globe and angle-valves are placed in pipe lines supplying steam, water, oil, etc., at any convenient point, wherever it is desired to be able to control or shut off the supply.

A needle-valve is one controlled by a small pin or needle working against a seat of the same size.

The valves used in feeding gasoline, kerosene, and most lubricating oils are of the needle type because the adjustment of feed can be regulated with great accuracy.

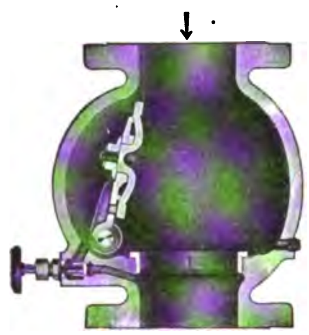
A safety-valve is one that is provided with a spring, or weight so that when the pressure exerted against it is below a certain amount, it is automatically closed, but as soon as there is an excess pressure the spring or weight allows the valve to open, to permit the excess pressure to escape. A safety-valve finds its use principally on a boiler, so that if steam is generated faster than it is being used, and the pressure thereby increases, the safety-valve will permit the excess to escape. This, of course, is done to prevent the explosion or rupture of the boiler from too high a pressure.



Section of Globe Valve with Renewable Disc.

669—VALVE, PIPE SPECIAL.—These are merely variations of the types described in the previous item, but given special names which spring from the service to which they are adapted, as follows:

A pressure-regulating-valve is one that keeps the pressure in the secondary pipe or container constant, no matter what the pressure in the initial pipe or container.



Section of Engine Stop-Valve.

An emergency or non-return-valve closes off a boiler as soon as its pressure is lowered below that carried in other boilers connected with it, and, vice versa, cuts in that boiler when its pressure is equal to that in the other boilers. Thus collapse of one boiler prevents any effect upon the others. This type of valve also prevents accidents by obviating the risky method of connecting a boiler into the header.

Exhaust-valves control the exhaust steam and lead it thru heating systems, feed-water heaters, or allow it to escape.

A throttle-valve for a steam engine is usually of the angle type.

An engine stop-valve is one by which an engine can be quickly stopped by pushing a button or pulling a string at a distant point. (See also Valve, pipe, basic types of.)

670—VALVE, PUMP, RUBBER.—This item refers to the hard rubber valves used in the water end of a pump. They are about 3½ inches in diameter and a half inch thick. There are two general types made, one for hot water and the other for cold water.

MANUFACTURERS (see catalog section):
New York Belting & Packing Co.
U. S. Rubber Co.

670A—VALVE, STEAM FOR STEAM PRESS.—The valve on a steam press is of special construction, fitted so that the downward and the upward travel of the piston are controlled by one lever.

MANUFACTURER (see catalog section):
Stevenson Co.

671—VANADIUM.—A mineral element whose compounds are ingredients in some clays, especially fire clays. Soluble vanadium compounds cause a green coloration on the surface of ware unless the clay is burned at a very high temperature. This often appears in the case of pieces of terra cotta. This discoloration can be washed off with water, but will continue to reappear until the salt is all out of the product. Vanadium compounds are rendered insoluble by burning the clay at a vitrification heat. An impervious slip will reduce green scumming due to this origin.

VASES, STONEWARE, see Stoneware vases, etc.

672—VAULT, SAFETY.—These are really large safes that are generally not portable, but are built into the building or office wall. Usually the walls, floor and roof are built of brick or reinforced concrete. The walls are fastened to an iron door frame by anchor bolts. The door like a safe is equipped with a combination lock. A vault should be used by every plant if the safe is not large enough to protect all valuable papers from the danger of fire. Good practice justifies making the vault large enough to hold all correspondence files. If this is done a fire will not destroy the records that are so necessary to take up and continue the business. There are also vaults made of all metal and portable. These are intended for use in an office where a permanent vault is not constructed or where additional space is needed. They are used to keep the books of account and to a certain extent are fireproof. The door has a combination lock. They are seldom large enough to hold correspondence files.

VESICULAR STRUCTURE, see Burning, results of overfiring.

VIBRATING SCREEN, see Screen, vibrating.

673—VISCOSITY.—Viscosity is determined by measuring the time required for a clay slip to flow thru an orifice 5/32 of an inch in diameter and dividing it by the time required for the same quantity of water at the same temperature to flow thru the same tube.

The term viscosity is also applied to the property of clays during fusion. After a clay has been heated to a point of complete vitrification, a little further but variable rise in temperature is accompanied by both swelling and softening of the clay, until it flows or gets viscous. The viscosity of the clay might be termed its resistance to flowing.

VITRIFICATION, see Burning, vitrification period of.

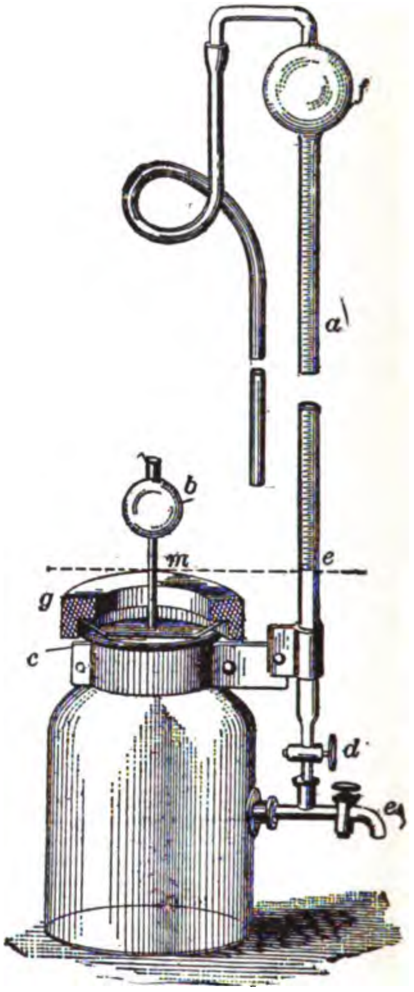
674—VIVIANITE.—A mineral ($Fe_2P_2O_8 + 8H_2O$) discovered in certain Pleistocene clays of Maryland, in which it occurs in small blue spits. Its probable effect on clays, if it appeared in large quantities, is unknown.

675—VOLUMETER.—A wide mouthed, glass stoppered jar, used for determining the porosity and specific gravity of clay. (See illustration.) In the center of the stopper is a circular opening in which is fitted the ground end of a short glass tube, m, which expands above into bulb, b, and is again contracted above it. Near the base of the jar is a glass stopcock, e, which connects above with burette, a, of 125 c. c. capacity, and graduated to tenths. Upper end of burette also widens to bulb, f, from top of which extends a bent tube for the attachment of a rubber tube, this tube being used to draw the liquid into the burette.

When stopcock in lower part of burette is open, the jar filled with liquid up to the mark on small glass tube, m, the liquid stands at the zero point in burette.

For determining volume of clay, the jar is filled with oil, ordinary kerosene with specific gravity of 0.8 (which must be accurately known), having been found satisfactory (see Ia. Geol. Surv., Vol. XIV, p. 107, 1904).

After jar is filled, the burette is drawn full of the liquid by suction thru the rubber tube, and held full by turning the burette valve or by means of a pinch-cock on the rubber. The stopper is now removed and the test piece of clay (still plastic and permeated with water) is carefully wiped dry of the coating film and put in jar.



Seger's Volumeter for Determining Porosity and Specific Gravity.

The test pieces, say, approximately three inches long, are allowed to dry till, on picking up a piece endwise between thumb and finger, the middle portion does not sag; in this regard, all samples should be treated the same. Care is taken not to splatter any of the liquid in placing block of clay in the jar. To prevent this, and to avoid breaking or otherwise marring the test piece by dropping it into the vessel, a small wooden float or support is of advantage. This float is conveniently made with a small eye or hook near each end, so that it may be handled by reaching in with two stiff bent-wire rods. In handling raw clays, some such an arrangement is quite necessary, but it may be dispensed with when the clays are burned. The stopper is now replaced, and by releasing the pinch-cock, d, oil from the burette is allowed to flow back into the jar until it stands at the top of the mark on the short tube.

The volume of clay is then indicated by the height of the liquid in the burette above the zero mark. The piece of clay is taken out and placed to dry while the volumeter is again filled to the zero points for the next test.

When dry, the clay is heated to 230 deg. F. to expel all hygroscopic moisture and, after weighing, it is placed in a vessel of oil until saturated. This usually requires from three to six hours for small test pieces approximately 3 by 1½ by 1½ ins. When saturated the piece is again weighed and its volume measured as before. Having now the wet and dry volumes, the percentage of cubical shrinkage in drying is easily calculated.

In measuring fire-shrinkage, it has been found good practice to use the same test pieces that were employed to determine drying shrinkage. In the case cited, these pieces were placed in a small muffle-furnace and burned to a temperature of 700 deg. to 800 deg. C. (1,292 to 1,472 deg. F.). By burning at this heat, dehydration and oxidation of the clay were completed; this is about the temperature at which common, porous, red building brick is burned. For many clays, vitrification has not begun at this heat, and they are left in the most porous condition attained during any part of the burning process.

The results of a number of determinations made on Iowa clays show that in two cases there was a slight expansion of the mass, indicated by a minus fire-shrinkage.

W

676—WAD-SQUEEZING.—When pottery is placed in the saggers for firing, it is necessary to seal the saggers before they are placed in the biscuit or glost kiln to prevent direct action of the flame upon the ware. To do this, long sausage-like rolls of clay are placed between the saggers. These wads are made by squeezing crude clay mixed with a percentage of sand thru round dies, by means of a wad-mill, similar in construction to a pug-mill.

MANUFACTURERS OF EQUIPMENT (see catalog section):
International Clay Machinery Co.
Mueller Machine Co., Inc.

677—WAGON.—A wagon is commonly known as a vehicle having four wheels, onto which a bed is fastened, and drawn by horse power. Its principal uses around a clay plant are to haul coal, ashes, cinders, rubbish, etc. In making any new foundations wagons are very good for hauling the excavated material and the sand, cement, etc. This is also true of any additions or improvements. Quite often surface clay plants and shale plants of small capacity use wagons to haul the raw material to the grinding or preparing machinery. Most wagons are made so that a solid bed can be put on to haul grain or anything of that nature and also so that a dump body can be used. (See also Wagon dump body.)

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

678—WAGON DUMP BODY.—A dump body of this kind is one that fits on an ordinary wagon body. The body usually has a bottom that will drop and allow the material in the wagon to fall as soon as a lever, located near the driver, is thrown. These dump bodies are very serviceable for hauling clay, ashes, coal, etc.

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

WAGON LOADER, see Loading machine.

679—WALL TILE.—The body of wall tile is made of white burning clay, and is burned just hard enough to resist scratching with a knife, being therefore very porous. Wall tile are molded in dry-press machines. They are then burned in saggers in a biscuit-kiln, after which they are removed and glazed, and then fired in a muffle-kiln at a much lower temperature. A great variety of shades, colors, and styles of decoration are produced. Sometimes the decoration consists of a relief design that has been impressed on the surface of the clay during molding; again, different colored glazes are used, or a considerable variation in shades of one color can be produced by varying the thickness of glaze over different parts of the tile. Print-work and hand-painting are also occasionally employed.

MANUFACTURER OF EQUIPMENT (see catalog section):
Mueller Machine Co., Inc.

680 — WALL-WHITE. — Sometimes brick come from the kiln without any trace of superficial discoloration or coating, but after they are subjected to moisture, an efflorescence appears; this is termed wall-white. (For cause, see Soluble salts.) The remedy seems to lie in making the walls in which these brick are used as impervious as possible by the use of well burned brick, thereby preventing or greatly reducing the absorption of moisture; also by equipping the walls with proper drainage and waterproofing the foundations. Paraffine or linseed oil will conceal the white incrustation, but will also make the brick darker; the walls may also be painted, but the paint is liable to peel off in the damp spots.

681—WASHING TROUGH.—Washing troughs are used in preparing for the market certain clays which contain finely divided impurities which can not be effectively removed by screening or handpicking. The equipment consists of an immense cylindrical or rectangular trough which contains a revolving shaft that carries a series of arms or stirrers. The clay may be taken directly from the bank to the washer, or may first be soaked in a pit to slake it. As the clay is put in the washing trough a stream of water is turned on it, and the revolving blades break up the clay so that it goes more readily into suspension. The water, with the suspended clay, then passes out at the opposite end from which the water entered.

By the time the water reaches the end of the troughing, which may have a total length of 500 to 700 ft. or more and have a gentle slope of not more than 1 in. in 20 ft., nearly all the sand has been dropped and the water and clay, after passing thru a screen of about 80 or 100 mesh, enter the settling tanks.

In order to economize space, the total length of the troughing is divided among several short troughs placed side by side, so that, during the washing process, the water and clay follow a zigzag course. Sometimes, in the case of very sandy clays, sand wheels are placed at the upper end of the troughing. These are wooden wheels bearing a number of iron scoops on their periphery. As the wheel revolves the scoops pick up the coarse sand which has settled in the trough and, as the scoop reaches the upper limit of its turn on the wheel, by its inverted position it drops the sand on a slanting chute, which carries it outside the trough.

The settling tanks are of wood, usually about 4 ft. deep, 8 ft. wide and 40 to 50 ft. long. They are usually placed parallel to each other and as soon as one is filled, the water and clay are diverted to another. When the clay has settled, most of the clear water is drawn off, and the cream-like mass of clay and water in the bottom of the vat is drawn off by means of slip pumps and forced into the filter-presses. When the water has been squeezed out the press is opened, and the sheets of clay are sent to the drying-room or racks.

Washing is applied chiefly to kaolins and other pottery clays, but is carried out to a less extent on fire clays, glass-pot clays, and ball clays.

WATCHMAN'S CLOCK, see Clock, watchman's.

682—WATER COLUMN.—These are attachments to a boiler for showing the height of water on the inside. They usually consist of a malleable casting which is placed so that the lower end will be below the lowest level of water that it is desired to carry, and its upper end will be above the highest level of water that it is desired to have. Both the lower and upper ends are connected to the boiler by pipe, the lower end having its pipe just above the highest point of the tubes and the upper end having its pipe connected in the top of the boiler. The water column has three gage cocks which are valves that can be opened to determine the height of the water in the boiler. The water column is also fitted with a gage glass, which is a tube of glass showing the exact level of the water in the boiler. The gage glass is supplementary to the gage cocks, but it gives continuous indications and therefore is more efficient than the cocks which give indications at only three points and only at intervals when opened. Either the cocks or the glass may become clogged so that it is advisable to use both to check on one another.

683—WATER GAGE COCK, BOILER.—In addition to gage glasses which are mounted on a water column to indicate the height of water in a boiler, gage cocks are used. These are usually three or more in number, at the lower end, middle and upper end of the water column. Each gage cock is really a valve which screws into the water column, and the other end of which exhausts in the open. In place of the regular valve handle, gage cocks are often equipped with chains, which can be pulled by the operator to open the valves. Springs are provided for closing the valves. Since either gage cocks or gage glasses can become clogged it is advisable to use both. (See also Water column.) These same gage cocks can be used to indicate the level of water in a tank, etc.

684—WATER GAGE GLASS, BOILER, ETC.—Tubes of glass of various sizes, about five-eighths inch in diameter and 14 inches long being the average size, which are used to show the level of the water in a boiler. A gage glass really forms a part of the water column, and therefore its lower end is placed above the tops of the tubes, and the water enters the gage glass in this way. The upper end is connected with the steam pressure in the boiler. The glass should be placed so that the limits of the high and low mark of water can be shown on it. A gage glass must be made to withstand the pressure exerted by the steam, and also the differences in temperature between the steam in the tube and the atmosphere on the outside.

685—WATER IN CLAY.—Clay contains two kinds of water in variable amounts: (1) mechanically combined water or moisture, and (2) chemically combined water.

Mechanically combined water is that which is held in the pores of the clay by capillary action, and fills all the spaces between the grains. When the grains are small, the clay may absorb and retain a large amount of water. If the grains exceed a certain size, capillary action is largely lost, and the water, when poured on the clay, quickly drains away. Thus fine-grained clays show high powers of absorption and retention, and coarse, sandy clays show a condition of minimum absorption.

Clay being very hygroscopic, greedily absorbs moisture when thoroly dry, and may, according to Seger, take up as much as 10% of its weight..

Water held mechanically in a clay will pass off partly by evaporation, but can practically all be driven off by heating the clay to 212 deg. F. The evaporation of the mechanical water results in a shrinkage of the clay mass, which ceases when the particles have all come in contact and before all the moisture is driven off, as a certain percentage remains in the pores of the clay. This is driven off during the first stages of burning. The shrinkage of the clay mass when the mechanical water is driven off may range from 1% or less in very sandy clays up to 10 or 12% in very plastic clays.

Effect of Water Content.

The mechanical water content may affect the behavior of the clay in many ways. For instance, a clay having a high absorption will shrink considerably during drying, and there is often danger of the ware cracking, especially if dried rapidly, owing to the rapid escape of the water-vapor. Again, if the material contains any mineral compounds which are soluble in water, the latter, when added to the clay, will at least dissolve a portion of them. The result is that, during drying, the water rises to the surface to evaporate and brings out the compounds in solution, leaving them behind when it vaporizes. Mechanical water may also help the fire gases to act on certain elements of the clay in a deleterious manner.

Chemically combined water is that which is present in the clay in chemical combination with other elements, and which, in most cases, can be driven out only at temperatures ranging from 752 deg. F. to 1,112 deg. F. This combined water may be driven from several minerals, such as kaolinite, which contains nearly 14%, white mica or muscovite with 4 to 5½%, and limonite with 14½%.

Unless a clay contains considerable limonite or hydrous silica, the percentage of chemically combined water is ordinarily about one-third the percentage of alumina present in the clay. In pure or nearly pure kaolin, there is about 14%; other clays contain amounts ranging from this point down to 3 or 4%, the latter quantity being found in some very sandy clays. The loss of combined water is also accompanied by a slight but variable shrinkage in the clay, which reaches its maximum some time after all the volatile matters have been driven off.

In many clay analyses the chemically combined water is determined as loss on ignition, but this, according to H. Ries, is incorrect if the clay contains carbon dioxide, sulphur trioxide, or organic matter, all of which are driven off, in part at least, at a dull red heat (see his book Clays: Occurrence, Properties, and Uses, p. 108).

WATER-SMOKING, see Burning, water-smoking period of.

686—WATER-SMOKING WITH FUEL OIL.—The principal point in water-smoking with oil is to get a hot flame on a small local spot to produce combustion, and then supply enough cold air to cool the gases down before they enter the kiln.

Another method in use is to use a drip burner. By this method the oil is dripped onto a metal plate, and burned there without being atomized. This system requires less care and saves some of the power required for an air blast.

687—WAVELLITE.—A mineral peculiar to white clays associated with manganese and iron ores on the northern slope of South Mountain, adjacent to Mt. Holly Springs, Pa. It occurs in aggregates of white nodules, and is apparently limited to a 40 to 50-ft. wide streak of residual clay. Also mentioned as having been found in Chester County, Pa. Chemically known as $Al_6(OH)_6(PO_4)_4+9H_2O$.

WEATHERING, see Clay, preparing and weathering.

688—WEATHER PROOF CLOTHING.—The nature of the clay products business requires that practically every plant has outdoor work, and this is especially true where the pit or shale bank is in the open. Many companies pay the men employed outdoors the same rate as other men and supply the waterproof clothing that is necessary. Around the kiln yard the lack of proper clothing often curtails the output of setting, burning and emptying. Weather proof clothing can be purchased either as a suit consisting of pants and coat which fit over the regular clothing worn by the men or as a coat only, which is long or short and intended to be worn over the regular clothing also. Heavy canvas or duck which is treated with a waterproof compound similar to tar, is used for some of the material and is generally known as slickers. A better grade of clothing is made by the canvas or duck absorbing fish oil which is waterproof. The latter does not become stiff during cold weather, as does the former. (See also Boots, rubber and felt.)

689—WEDGING-TABLE.—Wedging- or kneading-tables are used in a number of potteries to work the pugged clay into a homogeneous mass, instead of wedging it by hand. The machine consists of a circular table, about 6 ft. in diameter, with the top surface sloping outward. On this surface are two conical rolls, 20 to 30 ins. in diameter and about 8 ins. wide. These rolls have corrugated rims, and are attached to opposite ends of a horizontal axis, having only slight vertical play. The clay is placed on the table and, as the rolls travel around on it, is spread out into a broad band. A second axis carries two other pairs of rolls of the same shape but smaller size; these rolls travel in a horizontal plane, and act to press the clay together again. The action of the two sets of rolls is alternately vertical and horizontal, the clay first being rolled out flat, then forced back into a stodgy mass, and so on. The rolls make 10 to 12 r. p. m., and the machine kneads some two or three charges of 700 lbs. each per hour.

690—WELDING.—Welding is the process by which two pieces of metal are heated to such a degree that they unite with a third piece of molten metal to form one piece, the same as an original casting or sheet. The main use for this process around a clay products plant is to repair broken castings, plates, etc. Many times a casting is broken and the plant shut down until a new part is received. This may require several days, a week or even more. An oxy-acetylene welding outfit can repair almost any casting found in a clay products plant. It consists of two tanks, one containing oxygen and the other acetylene, and a torch or blowpipe which is connected to each tank by a rubber hose. The two gases are ignited at the end of the torch. The heat of the resultant combustion is in the neighborhood of 6,300 deg. F. An electric welding outfit consists of a strong current which jumps across an air gap between a carbon electrode and the metal which is to be welded. The resistance which the current encounters produces the high heat necessary to make the weld. Both of the welding outfits described are portable.

WET PAN, see Pan, wet.

691—WHEELBARROW.—A wheelbarrow usually consists of a single wheel pivoted between two shafts which are formed into handles at the other end and which also support the platform or body of the vehicle. In a broader sense, it is any of various small vehicles with one or two wheels, used for transporting loads up to 700 or 800 lbs., such as clay, burned ware, green ware to be set, coal, ashes, gravel, refuse, etc. The axle or axles of the wheels may run in cast iron or wooden journals, but it is better to have roller bearings. Wheelbarrows are used extensively for feeding clay to the preparing or finishing machine in a clay products plant, and also in wheeling coal and ashes to and from the boiler, dryer and kilns. In some plants they are used to move the dried material from the building or dryer to the kiln and the very large majority of plants use wheelbarrows for transporting the burned ware from the kiln to stock pile or to car and also from stock pile to car.

MANUFACTURERS (see catalog section):
Freese, E. M. & Co.
Hadfield-Penfield Steel Co.
International Clay Machinery Co.
Stevenson Co.
Toronto Foundry & Machine Co.

WHEEL, METAL, FOR VARIOUS USES, see Car wheel.

692—WHEELS, AUTO TRUCK.—Wheels for auto trucks must be heavy and strong to stand the large strains put upon them when the truck is loaded. Of course, all of them are equipped with roller bearings, and the usual type have wooden spokes. The rim is generally also of wood with a metal rim on the outside. Since there are several types of tires the wheels must be finished accordingly. There have lately been several types of wheels put on the market designed to obviate trouble in soft ground, etc. These have flanges attached to the sides of the wheels which extend beyond the tires. On good roads these flanges do not touch the ground or paving, as the diameter of the flanges is several inches less than the diameter of the outside of the tires. If poor roads are encountered and the wheels sink, these flanges make a larger bearing surface, and help to keep the wheel from sinking deeper. Shoes are provided on the flanges to increase the tractive force in the soft ground. (See also Automobile trucks, and Tire, several items.)

693—WHEELS, INDUSTRIAL TRUCK.—Industrial truck wheels are usually of small diameter, and metal is found to be the ordinary material used. At times when the wheels are larger than usual, wooden wheels, with metal rims to hold the tires, may be used. It is just as easy to make the entire wheel of one casting. (See also Tire, several items.)

MANUFACTURER (see catalog section):
International Clay Machinery Co.

694—WHEELS, TRUCK AND WHEELBARROW, HANDPOWER.—Manually operated trucks or wheelbarrows may be equipped with steel-tired wooden wheels, or cast-iron or wrought-iron wheels. Some are made entirely of one kind of metal; others have a cast-iron hub and steel spokes and rim, while still others have wrought-iron spokes and rim and cast-iron hub. A strong wheel is obtained by having a cast-iron rim and shrinking a band of steel over it.

MANUFACTURERS (see catalog section):
Easton Car & Construction Co.
Hadfield-Penfield Steel Co.
Steele, J. C. & Sons.
Toronto Foundry & Machine Co.

695—WHITE EARTHENWARE, SEMI-PORCELAIN, PEARL GRANITE.—These are potters' terms for the best quality of white earthenware. The names indicate to some extent that the object of the manufacturer is to produce an article resembling porcelain or china. The ware is, however, opaque and the body porous. The finest qualities of materials are used in this mixture with generally a little larger percentage of feldspar, thus producing a closer body and in very thin places a slight translucency. These wares are popular in all countries, both in their decorated and undecorated state.

696—WHITE GRANITE.—A term applying to the whiter and better grades of whiteware.

697—WHITEWARE.—That class of pottery which has a white or nearly white porous body, usually covered with glaze. There are a number of trade varieties of this ware, among them C. C. ware, white granite ware or ironstone china, semi-vitreous ware, semi-porcelain, and china. Theoretically, the difference lies in the degree of whiteness and of vitrification of the body.

In composition, whiteware corresponds very closely to a mixture composed of 52% clay, 33% flint (ground quartz), and 15% feldspar. The clay is introduced in the form of two materials, kaolin and ball clay. The former is a clay deficient in plasticity but burning to a clean white color; while the latter is very plastic and tenacious and fires in the kiln to a cream or buff color.

The ratio of the two kinds of materials is determined by the minimum amount of ball clay which will impart to the mass the working quality necessary for shaping the ware by the various processes. Since an excess of the ball clay results in the undesirable cream color, it is kept down to as low a percentage as possible.

Whiteware containing a relatively large proportion of ball clay or inferior grades of kaolin and ball clay, and showing for this reason more or less of a cream color, is known as C. C. (cream-colored) ware.

698—WHITEWARE: ITS RELATION TO PORCELAIN.—The difference between whiteware and porcelain is simply one of degree. For example, by increasing the content of feldspar in a whiteware body at the expense of the clay, and at the same time raising the burning temperature, greater contraction and the elimination of pore space would be obtained, and the resultant ware would have a dense, impervious body, which, due to the disappearance of air spaces and the increased volume of glassy matrix, would show translucency. The composition of a vitreous porcelain of the American type is: Kaolin and ball clay, 42%; whiting (calcium carbonate), 1.6%; calcined magnesia, 0.5%; flint, 36.3%; feldspar, 19.6%.

Comparison with the average whiteware body (see Whiteware) shows a lower clay content and an increased amount of feldspar. Additional fluxes are introduced in the form of carbonate of lime and magnesia, which tend to promote vitrification. The essential difference, therefore, lies in the fact that whiteware has a porous and opaque body, while porcelain is vitreous, dense, and translucent.

The physical properties of the two products differ in accordance with their structures. Thus, whiteware, being porous, is more resistant to shock and sudden changes of temperature. It possesses a lower coefficient of thermal expansion but is less hard. Porcelain is more difficult to produce successfully than whiteware. The advantages to be gained by making a porous product are (1) the whiteware body in plastic state is more easily fashioned; (2) it jiggers better and permits a larger output per man; (3) in biscuit firing, the lower content of fluxes and the absence of vitrification eliminates the danger of deformation; and for this reason the whiteware need not be bedded in sand; (4) in glazing, the porous surface absorbs the glaze more readily, thus increasing the speed of dipping. All these factors make for cheaper production.

Obviously, however, from the sanitary and esthetic standpoint, the impervious porcelain is to be preferred.

699—WHITEWARE, MANUFACTURE OF.—The various processes will be found described under: (1) Jiggering and Jollying; (2) Casting; (3) Kilns, biscuit and glost, placing; (4) Glazing, several items; (5) Decoration, underglaze; (6) Decoration, overglaze.

700—WHITING.—A form of calcium carbonate. Due to pulverizing and washing it is an impalpable powder. Used largely as a flux for fine chinaware and an important glaze ingredient. (See also Calcite and Calcium carbonate.)

WILLIAMS PATENT DECK SWEEPER, a patented swing hammer pulverizer equipped with a steam jacketed chamber to enable it to grind damp and wet materials. Made by the Williams Patent Crusher & Pulverizer Co.

WINDING DRUM, see Drum, winding.

WIRE CABLE, see Rope, wire and Wire rope compound.

701—WIRE CLOTH.—Wire cloth is used, in the clay industry, principally in the construction of screens and testing sieves. Its quality varies chiefly with the usage for which it is designed. Iron, brass and piano wire are most commonly used in its construction. Wire cloth is usually furnished to any desired degree of fineness up to 200 mesh. (See also Sieve, testing; and Woven wire.)

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.
Newark Wire Cloth Co.

WIRE, CUTTING, see Cutting wire.

WIRE ROPE, see Rope, wire; and Wire rope compounds.

702—WIRE ROPE COMPOUND.—A wire rope compound is a mixture of certain materials that are especially suited to lubricate wire rope. There are different grades of these compounds, all suited to some particular use, and some should be applied while hot and others while cold. The proper lubrication of a wire rope or cable is just as essential as the oiling of an engine, and incorrect lubrication, on account of the corrosion and decay that occurs on the inside of the rope, reduces the life of the rope immeasurably. The main object to be sought in lubricating wire rope is to reduce the friction caused by the interior wires on one another as they bend over drums and sheaves. There is also a certain amount of friction between the wires and the hemp center, which must be taken care of by the compound. Good results are obtained only when the proper lubricant for the particular service is used, for instance a track cable for hoisting up an incline from a pit requires a different lubricant than a steam shovel cable.

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

WIRE, WOVEN, see Woven wire.

703—WIRES AND CABLES, ELECTRICALLY INSULATED.—For the transmission of electric current copper wires are usually used and these are covered by some material to insulate them. Paper, rubber, cambric, and other cloth are used for insulation, mixed with gutta percha, tar, etc. For interior work the insulation is meant to protect the wire so that no current will leak from the wire. Many fires are started by poor insulation or a break in the insulation somewhere. For outdoor work the wire must be protected from the weather as the smallest amount of moisture around the wire will cause a short circuit if any other object is at hand to complete the circuit. A cable consists of a number of wires wound together but insulated from one another. The entire set is covered with a weatherproof compound.

MANUFACTURER (see catalog section):
Hadfield-Penfield Steel Co.

704—WIRING SUPPLIES AND TOOLS.—For putting up electric wires, wire stretchers are used to tighten the wire. Special long handled shovels are used to dig the holes for the posts and bars with points on the end for centering the post. The cross arms must be equipped with glass or porcelain insulators and the wire fastened to them. Pliers, nippers and a brazing outfit for soldering the wires together practically complete the equipment.

WITHERITE, see Carbonate of barium.

705—WOVEN WIRE.—These are screens made of wire woven together like house screens, but of heavier wire. In the finer grades brass wire is used, and it is made in almost any mesh desired, altho the screen made of fine wire is not practical for large output. Woven wire is used in stationary screens, vibrating screens, testing sieves, and lawns. The two latter are the places where most of the woven wire is used. (See also Wire cloth.)

MANUFACTURER (see catalog section):
Newark Wire Cloth Co.

WRENCH, CAR, see Car wrench.

706—WRENCHES, MONKEY, PIPE AND SPECIAL.—Wrenches are a very necessary adjunct around a clay products plant. Monkey and S- wrenches are especially suited for tightening nuts, bolts, etc. The former consists of two jaws, one of which is movable by means of a screw along the face of the wrench. It thus can be adjusted to any size. Some of the S wrenches are adjustable the same as a monkey wrench but with less movement, and others are made to fit only one size of nut. S wrenches derive their names from the original form that this type of wrench used to have. Alligator wrenches are flat with two jaws extending from the end at an angle of about 20 deg. The inside of these extensions have teeth that enable the wrench to grip the nut or bolt desired. There is no adjustment, as the teeth are made to fit each size. A pipe wrench is almost the same as a monkey wrench except that the jaws have teeth for gripping a pipe. In most pipe wrenches one jaw has a spring to assist it in gripping the pipe in the right way. Socket wrenches are very useful in replacing pump valves, pump heads, cylinder bolts, etc. They consist of a rod which terminates in a socket made either square or hexagonal to fit over the bolt or nut that it is desired to tighten or loosen. The other end is made into a hexagonal head which can be turned by a wrench, or holes are provided thru which a rod is placed and the wrench turned by means thereof.

Y Z

707—YELLOW OR ROCKINGHAM WARE.—This is used largely for kitchen and culinary purposes. It is composed of a crude, yellow clay without any other admixture, the clay being simply mixed with water to put it in plastic condition, about the consistency of fresh putty. It is generally coated with a cheap glaze, known as raw glaze. Much of this ware is fired but once. Having been thoroly air-dried, it becomes strong enough to be dipped in the glaze, thus necessitating but one firing.

708—ZINC OXIDE.—This mineral agency (ZnO) gives a porcelain body an excellent color when used in small quantities, altho about 0.05 equivalent gives a rather objectionable bluish or greenish tinge to the body. It has the disadvantage of tending to opacify a body when over 0.02 or 0.03 equivalent is used. A high per cent. causes bodies to give trouble from cracking in the molds. It shivers badly with as low as 0.1 of an equivalent. Trouble from cracking in molds can be overcome by calcining the zinc oxide.

In glazes zinc oxide in limited amounts helps brilliancy, glossiness and fusibility, a wider heat range and greater elasticity which diminishes the tendency to craze. Zinc oxide is not necessary in raw lead glazes unless to counteract crazing in the more fluid of those relatively high in lead and low in alumina. With ZnO of high amounts the equivalent of lead may be reduced and yet maintain equal fluidity of glazes with a slightly less yellow tinge. It is best to keep ratio of ZnO to CaO at not more than 1 to 1 and generally from 1 to 2 and 1 to 3.

709—ZIRCONIA.—This is the oxide of zircon, with a formula of ZrO_2. It has a melting point of 2,590 deg. C. It is highly refractory, but hard to obtain in a pure state. It does not shrink at high temperatures. It is black in color. It is a new refractory material and its future development may be considerable.

Do Not Miss Two of the Most Useful Features of This Cyclopedia:
On Page 124 Departmental Index of Plant Equipment.
On Page 126 Index to Statistical Section.

Clay Products Associations

The several associations in the clay products industry are doing very constructive work in their individual fields. We list herewith some of the more important activities and accomplishments, realizing, however, that this limited space can only afford general information and cannot touch upon any details.

In every case the industrial associations have increased the consumption of the product, due to the publicity attained either by direct advertising or by distributing information to its customers.

At the same time these associations have reduced the cost of manufacture by standardizing the sizes produced, thereby eliminating unnecessary stock, and by making public information on the processes, fuel and supplies used. All of these associations have helped to eliminate the old feeling that everyone should keep secret any improvement or betterment that he develops. This broad minded policy and spirit has greatly improved the condition of every manufacturer of clay products.

In addition, these associations have greatly benefited the purchasers of clay products as well as the general public, because of the increased production, reduced costs, research, campaign for lower freight rates, and standardization, as well as by the information gained thru publicity.

Ceramics

The American Ceramic Society, a technical and scientific organization to advance the ceramic arts and sciences, was founded in 1899. Each year there has been reported a remarkable growth in membership, scope and interest, and the society is still reaching into fields of new endeavors which the modern industrial fabric of this country requires. Its present membership totals approximately 1,500. This includes associate members, active members, corporation members, industrial or trade association members, and honorary members.

The Society is divided into groups known as Divisions, which are defined by industrial distinctiveness. At present the Divisions are Art, Enamel, Glass, Heavy Clay Products, Refractories, Terra Cotta, and Whitewares. Each Division has its own organization and committees, and the privilege of initiative or choice in operation. Each is promoting research and has the aim of advancing the arts and sciences in its particular field. The Divisions deal exclusively with the technical and scientific problems of manufacturing.

Local Sections are organized in certain geographical centers to develop sociability and to keep before the members, between annual conventions, the purpose of the Society. These groups meet frequently.

The chief activity of the Society is its co-operative research work. This consists of investigation, inquiry, scrutiny, examination, and inspection, of facts or principles. Review of literature, compilation of bibliographies, conducting of symposiums, and studying manufacturing requirements are methods of research, and interpreting the fundamental sciences into terms of factory practice is the result.

The American Ceramic Society always has been and will continue to be an organized influence stimulating co-operative research by furnishing the forum and the means of publication. Its Committees suggest researches and, when called upon, plan them in detail. Data are collected, classified, and published.

The present officers are F. H. Riddle, president; Dr. E. W. Tillotson, vice-president; R. K. Hursh, treasurer; Ross C. Purdy, secretary; B. E. Salisbury, R. M. Howe, F. K. Pence, R. H. Minton, and F. B. Ortman, trustees. The executive office is located at Lord Hall, O. S. U., Columbus, O.

Face Brick

The American Face Brick Association was formed in 1912, to promote the use of face brick. One of the chief activities of this association has been its advertising campaign to acquaint the public with the economy, beauty, attractiveness and utility of using face brick for the outside walls of a building. The results of this type of advertising campaign are cumulative, that is, they are felt not only at the time of the campaign but for years afterward. This campaign coupled with that of the Common Brick Manufacturers Association and the Hollow Building Tile Association has created an amount of good will for clay products construction that it is impossible to estimate. Part of the results are shown in the articles on this subject that are appearing in the reading pages of magazines of national circulation.

The numerous inquiries for the books, plans and specifications of this association show conclusively that the gospel of brick construction is being spread broadcast, with wonderful results. This association was the pioneer in the clay products industry in affording informative service to the public by distributing plans and specifications of brick construction.

The "Face Brick Manual" was the first publication that gave definite information and set standards of construction for face brick walls. It is the standard for that construction today.

Another activity that has been backed by this association to the fullest possible extent is the attempt to obtain fair and equitable revision of the existing railroad tariff. The National Paving Brick Manufacturers Association and the Hollow Building Tile Association have worked in perfect harmony with the American Face Brick Association on this question.

This association is divided into sections thruout the country. These sections hold meetings monthly, and exchange views on subjects of local or territorial interest, such as labor supply, fuel and car supply. This exchange of views achieves far better results than a meeting only once a year.

The headquarters are at 130 N. Wells St., Chicago. The officers are Eben Rodgers, President; B. Mifflin Hood, T. P. Cuthbert, vice-presidents, and R. D. T. Hollowell, secretary. G. C. Mars is Director of Service.

Common Brick

The Common Brick Manufacturers Association was formed in 1918 to look after the interests of the common brick manufacturers of the country. This branch of the industry had been somewhat neglected by other associations up to that time, and the output of common brick had been declining. Several special activities have bettered these conditions very considerably and are improving them continually.

One of these special activities is the advertising campaign started and being conducted by the association. All of this advertising carries the association trade mark. The public is being educated to think and talk brick construction, where they were formerly familiar only with frame and stucco. The advertising campaign of this association links up with similar campaigns conducted by the American Face Brick Association and the Hollow Building Tile Association.

A second special activity is the development of the Ideal Wall as a factor of economy in the construction of brick houses, especially of homes and other structures not more than two or three stories in height. This type of construction is described in detail on page 59.

The development of the Ideal Wall has led to another special activity, namely the correction of the building codes of the various cities and communities. This correction must be made in many cases in order to permit the use of the Ideal Wall. There should also be more standardization of building codes for the regular solid brick wall, as it has been shown that in many cases useless thickness of brick walls has so increased the cost of a building that it was very difficult to compete with inferior materials.

This association is assisting in the fire tests and load tests of building materials being conducted by the U. S. Bureau of Standards.

A book published by this association called "Brick, How to Build and Estimate," is the standard manual of common brick construction.

The officers are president, Charles H. Bryan; vice-presidents, William N. Carey, Fritz Salmen, John P. Cahoon, and B. F. Weber; treasurer, Ernest S. Barkwill and secretary Ralph P. Stoddard. The headquarters are at Cleveland Discount Bldg., Cleveland, Ohio.

Sewer Pipe

The Clay Products Association is an association of sewer pipe manufacturers. It was formed in 1917 and the late George H. Tefft was the first secretary and a moving spirit in the organization and upbuilding of its influence.

The association was formed to work hand in hand with the eastern association in the promotion of vitrified, salt glazed, sanitary sewer pipe, segment block and other products manufactured by its members. Another purpose of the organization was to create and maintain high standards of manufacture.

The Clay Products Association has done and is still doing great work in co-operation with the United States Public Health Service and state and local boards of health for improving sanitary conditions, and with the National Board of Fire Underwriters to bring about better construction of buildings, especially chimneys, by securing the enactment of state laws, city ordinances and building codes requiring the use of fire clay flue lining and thus reducing the enormous waste and loss of property by fires that are caused by defective flues.

The headquarters of this association are located in the Chamber of Commerce Building, Chicago, and the present secretary is George C. D. Lenth.

Hollow Tile

The Hollow Building Tile Association was organized in 1918 for the purpose of promoting the greater use of hollow building tile. Originally formed with approximately 50 members the association increased its membership to 100 in 1922. Members of the association manufacture, it is safe to say, about 75 per cent. of all hollow tile produced in the U. S. The organization maintains an advertising department and an engineering department. Advertising is done thru mediums such as farm journals, architectural and building papers generally and magazines of national circulation. A plan service is maintained comprising complete plans, specifications and quantity surveys of about 17 residences, four garages, four hog houses and one public garage. These plans are sold at a very nominal price to persons planning to use hollow tile in the structure.

A book published by this association "Manual of Hollow Tile Construction" is accepted everywhere as the standard for this type of construction. It shows details of building walls with the cells vertical or horizontal, and explains how to build lintels, corners, window jambs, etc.

The engineering department of the H. B. T. A. is an important part of the organization. It is the duty of this department to safeguard the interests of hollow tile, straighten out engineering problems which arise in the field and extend engineering and technical service and help on the job.

The association has a permanent secretary, E. R. Sturtevant, who looks after and manages the affairs of the organization and acts in the capacity of secretary-treasurer. Officers and directors of the association for 1922 are:

President, James T. Howington, Coral Ridge Clay Products Co., Louisville, Ky.

Vice-president, Wm. Hutton, Jr., Troy (N. Y.) Fireproofing Co.

Directors, F. F. Anness; H. C. Downer; F. R. Hale; H. R. Straight; J. J. Amos; J. H. Payne; H. M. Keasbey; T. J. Neiswanger; S. D. Knight; J. A. Dailey; Robert Gamble; R. G. Wallace.

National Brick

The National Brick Manufacturers' Association is probably the oldest of the clay products associations. Whilst it is the association from which many of the other associations have sprung, it has no official or working connection with them.

On account of the steady growth of the clay products industry, it was found that one association was inadequate to cover all the activities and branches of the industry. By means of individual associations, each working on the problems and interests that appeal to, and concern only one branch of the industry, far greater progress has been made for all concerned.

The officers of the National Brick Manufacturers' Association are Thomas E. Wilson, president; R. C. Burton, Jotham Post and Douglas F. Stevens, vice-presidents; John W. Sibley, treasurer and Theodore A. Randall, secretary. The secretary's office is located in Indianapolis, Ind.

Labor Conditions

The National Clay Products Industries Association was brought into existence by clay products manufacturers principally in the refractory industry, in the fall of 1920, but has since gained members from all the other clay products branches. Its principal object and aim is to promote and maintain industrial tranquility in the entire clay products industry, accomplishing this through a competent staff of "open shop" clay workers, experienced in every job of the different branches of the industry whether it be in the building brick, hollow tile and paving brick industries, manufacturing common brick, face and enamel brick and hollow building tile; or terra cotta, floor and wall tile, faience, decorative tile and all pottery industries; or refractory industries manufacturing brick and all shapes of fire clay, silica, magnesite, bauxite, chrome and silicon carbide and glass house refractories; or sewer pipe, segment and solid block, vitrified products, drain and roofing tile industries, and all others.

This association has given over a great deal of time, thought and energy to maintain sources of supply of experienced clay products workers, so that other industries will not absorb these, to the detriment of the clay products industry.

This association believes in individual contract relations between employer and employe, without discrimination either for or against union or independent workers.

It is officered by some of the most prominent clay products manufacturers of the country and ably managed by an industrial relations expert with many years of experience, as its Commissioner.

Paving Brick

The National Paving Brick Manufacturers' Association is formed of the manufacturers of vitrified paving brick. Their activities are centered on spreading information about the economy, satisfaction and dependability of brick paving for city streets and country roads. To this end they publish a monthly called "Dependable Highways" and distribute it to engineers, city and highway officials and others who plan paving and allot contracts, in order to acquaint them with the superior qualities of brick, compared to inferior competing materials.

One of the biggest things that this association has done is assisting the U. S. Department of Commerce to reduce the number of sizes of paving brick. In 1921 and former years there were as many as 66 varieties of sizes manufactured. This has now been reduced to seven. This step will assist the manufacturers to reduce the cost of manufacture per thousand and also reduce the cost of the delivered brick for a road. This latter reduced cost will help to increase the amount of brick paving laid.

This association has also been instrumental with the American Face Brick Association, The Hollow Building Tile Association and The Common Brick Manufacturers' Association in financing the Joint Research Council. This research is investigating manufacturing operations in order to reduce waste by showing the best method of carrying on each operation in a plant.

The U. S. Bureau of Mines is furnishing part of the funds and equipment for this work. It is under the able direction of R. T. Stull, Supervising Ceramist of the Bureau of Mines.

In 1920 the association published a book containing specifications for the design and construction of brick paved roadways. Numerous alternatives of methods and materials are given for the essential parts of all brick pavements in this excellent publication.

The headquarters are in the Engineers Building, Cleveland, Ohio. Maurice B. Greenough is secretary, assisted by a capable corps of engineers and experts.

The other officers of this association are: S. M. Duty, Cleveland, chairman of the board; O. W. Renkert, Canton, Ohio, president; W. P. Blair, Cleveland, and W. M. Lasley, Chattanooga, Tenn., vice-presidents; and C. C. Barr, Streator, Ill., treasurer.

Terra Cotta

The National Terra Cotta Society was organized in December, 1911, with fifteen companies. Its membership is now twenty-six, including practically every manufacturer of terra cotta in this country.

The objects of the Society are to encourage the production of the best materials, the maintenance of high standards of work, to spread knowledge of good architectural Terra Cotta thru advertising, educational literature, etc., and to co-operate in the investigation and study of the more important technical problems of the business, advancing mutual interests in every legal and proper way, and without directly or indirectly maintaining prices or suppressing competition.

Under the above policy, to which the Society has strictly adhered, it has accomplished in the eleven years of its existence a very great improvement in the technical quality of product, methods of workmanship and public appreciation of the value of Terra Cotta and of its appropriate use in better architectural design for all classes of buildings.

The Society's publications consist of a very valuable and complete technical reference work entitled "Architectural Terra Cotta Standard Construction," containing seventy plates of typical details showing the manner of constructional design and methods of installation, a series of illustrated brochures covering the application of Terra Cotta to all classes of buildings, and the dissemination among its members of periodical pamphlets containing the results of experimental research work conducted by its fellows with the United States Bureau of Standards, Washington, D. C.

The present officers of the Society are as follows:

Walter S. Primley, president; Atholl McBean, first vice-president; O. W. Ketcham, second vice-president; Walter Geer, Jr., treasurer; F. S. Laurence, executive secretary.

Refractories

The Refractories Manufacturers' Association is a voluntary organization of manufacturers of brick used in metallurgical and other industries to resist high heats. It was organized in 1916 and its membership at the present time (March, 1922) is made up of ninety-six firms and corporations whose output is estimated to be about seventy-five per cent. of the production of this material in the United States.

Its government is in the hands of an Executive Committee selected by district organizations and elected by the membership at large.

Its objects, as expressed in its Constitution are: To standardize the dimensions of refractory brick and shapes most widely used; to establish and conduct research for the improvement of refractory products; to cooperate with scientific and technical associations in determining suitable tests; to assist consumers in obtaining better service from refractories; to institute modern methods of accounting; to collect and disseminate statistical information; to encourage fair competition; to create friendly relations in the refractories industry.

Its officers for the current fiscal year are: Arthur P. Taylor, of Cincinnati, Ohio, president; Frank R. Valentine, of Woodbridge, N. J., vice-president; C. C. Edmunds, of Pittsburgh, Pa., treasurer and Frederic W. Donahoe, of Pittsburgh, Pa., secretary. National headquarters are at Pittsburgh, Pa.

Additional Associations

In addition to the associations listed above the following associations are located at the several addresses shown:

Associated Tile Manufacturers, Beaver Falls, Pa. Members are the manufacturers of wall, floor and decorative tile.

U. S. Potters Association, Chas. F. Goodwin, Secy., East Liverpool, Ohio. The membership consists of the manufacturers of pottery of all classes thruout the country, especially of chinaware.

Canadian National Clay Products Association, Gordon C. Keith, Secy., 435 Grace St., Toronto, Ont., Can. The membership is open to the manufacturers of clay products in Canada, regardless of the location or the class of product. This association holds an annual convention and is always working for the betterment of the clay products manufacturer of Canada.

Sanitary Potters' Association, George G. Dyer, Secy., 1003 American Mechanic Building, Trenton, N. J. The members of this association are the manufacturers of sanitary ware, such as bathtubs, washtubs, drinking fountains and other glazed pottery ware used in connection with plumbing . This association holds a membership in the Chamber of Commerce of the United States.

Departmental Index of Plant Equipment

This index is a classification of the items in the cyclopedia according to the various plant departments, burning, setting, molding, etc., and was added as a guide to anyone desiring to obtain all information possible covering a special department of his plant. The index is divided under three general heads, General, Pottery and Heavy Clay Products. Those departments that are similar in every plant are indexed under the head General, including such items as Executive or office equipment, Power transmission equipment, etc. In other departments such as Grinding and preparing, in which the equipment used in a pottery is different from that used in a plant producing heavy clay products, we have listed each type of plant separately.

Suppose you are looking for all information possible regarding the burning of face brick. Looking under the general head Heavy Clay Products you will find the subhead Burning, under which is listed the number of every item which contains information on that subject. In order to eliminate any unnecessary detail we have aimed to include only those items that are somewhat special for each department. Babbitt metal, bushings, lubricants, pulleys, gears, belting and several other items, for instance, are used in every department where machinery is employed. We have avoided a long list including many of these smaller items by grouping them under the heading Repair crew equipment, Power transmission equipment, Building, etc.

We trust that this index will assist the readers in finding the related information quicker and with more satisfaction. We believe that this is the first index of this kind, by means of which a manufacturer who is having trouble with one department or who wishes to improve the conditions of one department can quickly locate the general information and list of processes or equipment used in that department.

The numbers of the items refer to the numbers in the definition section.

MANUFACTURED PRODUCTS.—Pottery

See items 17, 34, 40, 64, 92, 106, 120, 121, 165, 166, 236, 237, 239, 240, 253, 315, 363, 364, 415, 420, 455, 466, 476 to 483, 488 to 492, 519, 529, 543, 547, 557, 561, 582, 595A, 611 to 614, 616, 679, 695 to 699, 707.

Heavy Clay Products

See items 67 to 69, 71 to 73, 204, 265, 270, 287, 298, 334, 336, 344B, 524, 541, 562, 578, 592, 607, 631, 632, 633, 639, 640.

General

EXECUTIVE OR OFFICE.—Equipment

See items 93, 118, 136, 137, 254, 262, 264, 425, 426, 437, 522, 537, 551, 576, 662, 672.

Processes and General Information

See items 2, 16, 22, 65, 90, 110A, 112, 128, 145, 161, 189, 247, 261, 346, 347, 355, 356, 426A, 436, 583.

BUILDING.—

See items 107, 110, 145, 278, 293, 450, 567, 624.

MACHINE SHOP EQUIPMENT.—

See items 122, 164, 195, 210B, 277, 319, 369, 403, 456, 465, 467, 549, 550, 566, 605, 644, 690, 706.

REPAIR CREW EQUIPMENT.—

See items 15, 26, 42, 43, 48, 50, 104, 114, 209, 303, 362, 370, 532.

FUEL.—**Processes and General Information**
See items 75, 77A to 85, 272, 288, 295, 297, 316, 332, 353, 438, 498, 600, 609, 610, 651, 667, 686.

Conveying and Transporting Equipment
See items 20, 25, 32, 36, 76, 77, 100, 102, 113, 124, 140, 151, 152A to 157, 653, 677, 678, 691 to 694.

Material Used as Fuel
See items 139, 141 to 143, 285, 286.

POWER.—**Steam Equipment**
See items 10, 19, 27, 57 to 62, 71, 108, 109, 135, 146, 176, 203, 249, 251, 263, 272, 276, 291, 292, 312, 331, 340, 342, 351, 417, 462 to 465, 525, 539, 559, 600, 623, 659, 664 to 666, 668, 669, 682 to 684.

Electrical Equipment
See items 289, 304, 323, 430, 625, 649, 703, 704.

Internal Combustion Equipment
See items 248, 285, 286.

General Equipment
See items 7, 26, 55, 110, 238, 296, 352, 413, 414, 440, 442, 443, 446, 448, 449.

PUMP.—
See items 312, 504 to 511, 628, 670.

POWER TRANSMISSION EQUIPMENT.—
General Equipment
See items 15, 26, 29, 39, 86, 104, 162, 163, 238, 264, 317, 350, 369, 413, 414, 437A, 440, 442, 443, 446, 500, 501, 530, 532, 533, 563, 564, 599.

Drive Equipment
See items 41 to 51, 115, 211 to 213, 280, 300 to 303, 332A, 342A, 423, 538.

CLAY.—**Minerals Found Mixed in Clays**
See items 13, 87, 88, 306, 324, 325, 333, 339, 345, 349, 359, 367, 407, 408, 416, 419, 421, 427, 432, 434, 435, 446A, 459, 512, 518A, 520, 523, 536, 574, 580, 594, 595, 621, 627, 643, 645, 671, 687.

Qualities, Tests and Testing Instruments for
See items 1, 3, 17A, 21, 63, 77A, 86A, 91, 133, 147A, 188, 240, 257, 279, 290, 330, 458, 471, 472, 484, 521, 572, 575, 584, 589, 596, 596A, 629, 630, 634, 635, 673, 675.

Raw Materials Used for Manufacturing Clay Products
See items 37, 123, 202, 294, 371, 406, 518, 544, 548, 565, 577, 709.

Unclassified Data
See items 11, 111, 125 to 127, 130 to 132, 208, 210A, 290A, 304A, 320, 422, 495, 579, 622, 685.

CLAY WINNING.—**Pit-Mine Digging Equipment**
See items 105, 116, 124, 196, 198, 201, 205, 210A, 249A, 250, 299, 427A, 468, 473, 552, 568 to 571.

Transporting Equipment
See items 4, 25, 36, 76, 95, 97, 101, 113, 151, 152A, to 154, 157, 164, 197, 214, 284, 335, 410 to 412, 433, 597, 641, 653, 655, 657, 677, 678, 691, 692 to 694.

General Equipment and Supplies
See items 10, 15, 26, 29, 39, 54, 57 to 62, 66, 86, 138, 210, 210A, 235, 238, 264, 275, 341, 405, 423, 461, 493, 504, 505, 510, 533, 688.

Unclassified Data
See items 53, 104, 134, 447, 619.

Pottery

GRINDING OR PREPARING—**Equipment**
See items 5, 18, 30, 56, 77, 100, 119, 124, 313, 368, 404, 431, 452 to 454, 457, 460, 502, 503, 553 to 556, 558, 606, 657A, 701, 705.

Processes and General Information
See items 9, 31, 129, 318, 418, 590, 617.

MOLDING.—**Equipment**
See items 241, 246, 259, 260, 365, 437A, 451, 470, 475, 485 to 487, 499, 509, 585, 628, 689.

Processes
See items 144, 195A, 199, 233, 266 to 268, 327, 338, 365, 469, 496, 546, 637, 660, 676.

GLAZING AND DECORATING.—**Raw Materials and General Information**
See items 33, 33A, 55A, 74, 89, 160, 182, 183, 258, 269, 273, 274, 307, 308, 314, 422, 441, 444, 446A, 544, 591, 620, 700, 708.

Equipment
See items 6, 7, 30, 241, 282, 283, 309, 657A.

Processes
See items 74, 177 to 186, 249B, 281, 305, 310, 318, 321, 322, 327 to 329, 348, 409, 497, 586 to 589, 598, 601, 602, 615.

DRYING.—**Equipment**
See items 8A, 14, 55, 109, 110, 217 to 230, 255, 284, 424, 424A, 433, 451, 511, 526, 604, 618, 636, 648, 663.

Processes and General Information
See items 216, 232, 233, 288, 354.

SETTING.—**Equipment**
See items 94, 95A, 98A, 98B, 155, 405, 540, 544, 559A, 654 to 657, 661, 691 to 694.

BURNING.—**Equipment**
See items 55, 71, 108 to 110, 148, 176, 203, 255, 263, 373 to 376, 378, 385, 389 to 394, 397, 399, 513 to 517, 526, 540, 600, 636.

Processes and General Information
See items 28, 78 to 85, 267, 276, 388, 542, 686.

CONVEYING AND TRANSPORTING EQUIPMENT.—**Handling Raw Material and Manufactured Ware**
See items 25, 32, 149 to 159, 335, 641, 642, 446 to 648, 652 to 657.

Heavy Clay Products

GRINDING OR PREPARING.—
Grinding Equipment
See items 100, 167 to 172, 200, 224, 238, 256, 313, 368, 425A, 431, 452 to 454, 502, 503, 606.

Conveying and Elevating Equipment
See items 77, 98C, 115, 124, 149 to 151, 152A to 159, 242, 243, 245, 409A, 626, 651, 667.

Screening Equipment
See items 457, 460, 553 to 556, 558, 701, 705.

Processes and General Information
See items 9, 129, 244, 318, 590, 617.

MACHINE OR PRODUCING.—**Machine for Forming Ware**
See items 24, 27, 173, 174, 191, 192, 193, 195, 195B, 234, 271, 324A, 337, 343, 474, 492A, 499, 527, 581, 592A, 593, 603, 608, 638.

Processes and General Equipment
See items 192A, 226, 233, 252, 402, 428, 429, 437A, 451, 475, 528, 628, 668, 659A, 670A.

Supplies
See items 31, 175, 341, 342.

DRYING.—**Equipment**
See items 8A, 14, 32, 32A, 55, 94, 98 to 98B, 101, 115, 155, 203, 218 to 222, 224 to 230, 255, 284, 344, 344A, 366, 424A, 433, 451, 466A, 511, 526, 597, 604, 636, 648, 650, 663.

Processes and General Information
See items 8, 9, 216, 217, 223, 231, 232, 354.

SETTING.—
See items 32, 32A, 98 to 98B, 155, 157, 324A, 405, 559A, 560, 648, 654 to 657, 661, 691 to 694.

BURNING.—**Equipment**
See items 55, 71, 95A, 108 to 110, 148, 176, 203, 240A, 255, 263, 372, 373, 376 to 384, 386, 389, 390, 392, 394 to 396, 398, 399, 513 to 517, 583A, 600, 636.

Processes and General Information
See items 28, 52, 77A to 85, 117, 267, 276, 372, 387, 388, 400, 401, 542, 680, 686.

CONVEYING AND TRANSPORTING EQUIPMENT.—**Handling Raw Material and Manufactured Ware**
See items 25, 29, 32, 32A, 36, 39, 70, 96, 98 to 99, 113, 149 to 159, 243A, 409B, 531, 626, 641, 646 to 648, 652 to 657.

Index to Statistical Section

The Statistical Section has been greatly enlarged from our original plans. It contains not only many valuable statistics, some not heretofore published, but also important instructions for locating a clay products plant, testing clay and clay land, prospecting for deposits, and other data for determining the value of a certain raw material.

It also contains information concerning the purchase and use of fuel and other supplies, instructions for installation and operation of many pieces of equipment thruout a plant, and in addition the most important standard tests for determining the quality of manufactured ware.

The items are listed under the same headings and numbers as used in the definition section, and this index shows the page numbers for each item.

Item .... Page
2—Accounting 128
25—Automobile Trucks 129
37—Bauxite 127
41—Belt Dressings 129
45-46-47—Belting, see Elevator Bolts 166
57—Boiler 185-198
58—Boiler Compound 166
62—Boiler Tubes 197
67—Brick, Building 130-131-183
Brick, Sewer 131
72—Brick, Paving 131
84—Burning, Vitrification Period of 136
96—Car Loaders 198
114—Chain Block 199
115—Chain Drive, Sprocket 134
116—Chain, Load 200
123—Chrome 127-135
126—Clay Deposits, Classification of 136
Also see definitions of clay under Brick, Sewer 131
132—Clay, Prospecting For 137
133—Clay Testing 142
Also see Sieve testing 196
134—Clay Winning 133-196
138—Clutch 200
140—Coal Handling Equipment 155
141—Coal, Heat Value of 163
Also see Flue Gas Analysis Apparatus 171
Also see Fuels, comparison of 172
142—Coal, How to Select 148
145—Concrete 151
146—Condenser 162
148—Cones, Pyrometric 197
151—Conveyor, Belt 152
154—Conveyor, Drag-Plate and Bucket 155
155—Conveyor, Heavy Duty Monorail 155
158—Conveyor, Screw Or Spiral 156
163—Coupling, Shaft 199
168—Crushers, Gyratory 156
172—Crushers, Two Roll and Compound 156
177—Decalcomania, Chromo or Litho-Transfer Work 157
183—Decorative Coloring Materials 157
189—Depreciation 157
192—Die, Drain Tile 155
202—Dolomite and Magnesite 127
203—Draft Gage and Meter 157
204—Drain Tile 155-158
210B—Drill Press 199
Also see Machine Shop equipment 197
212—Drive, Rope 162
213—Drive, Silent Chain 162
214—Drum, Winding 163-198
223—Dryer, Relation of Air to 163
228—Dryer, Steam 163
Also see Pipe-equalization tables 182-184
235—Dynamite 163

Item .... Page
240—Electrical Porcelain 164
242—Elevator Bolts 166
245—Elevator or Bucket Conveyor 167
251—Expansion Joint for Piping 168
258—Feldspar 186-197
263—Fire Brick 168-185-195
Also see Refractories 188
Also see Chrome 135
272—Flue Gas Analysis Apparatus 170
Also see Coal, heat value of 163
Also see Fuels, comparison of 172
278—Foundations 172
279—Freezing Test—See Drain tile 158
281—Frits 172
285—Fuel Oil 174
Also see Fuels, comparison of 172
286—Fuels, Comparison of 172
Also see Coal, heat value of 163
Also see Flue gas analysis apparatus 170
297—Gas Producers 173
301—Gear 174
General Information 200
Government Statistics 126
316—Grates and Grate Bars 175
331—Heater—Feed Water 176
335—Hoist—See Drum, winding 163
336—Hollow Block and Brick 176
344—Hygrometers 178
386—Kiln, Down-Draft, Design and Construction 178-185
392—Kiln Insulation 179
403—Lathe, see Machine Shop Equipment 197
410—Locomotives, Electric Storage Battery and Trolley 180
—Machine Shop Equipment 197
430—Motor, Electric 181
438—Oil Burner—See Pipe-equalization tables 182-184
462—Pipe and Pipe Fittings 181-184
Also see Expansion Joint 168
463—Pipe Coverings 184
467—Planer, see Machine Shop Equipment 197
491—Pottery, Materials Used in Manufacture 186
500—Pulleys 186
501—Pulleys, Special and Slotted 187
504—Pump 187
524—Refractories 127-188
Also see Fire brick 168
532—Rope, Manila 193
533—Rope, Wire 193
545—Sand—Lime Brick 126
562—Sewer Pipe 194
565—Shale—See Brick, sewer 131
566—Shaper, see Machine Shop Equipment 197
575—Sieve, Testing 196
Standard Sizes 126
604—Steam Traps 196
605—Steel 196

STANDARD SIZES

Standard Sizes of Paving Brick

The sizes of paving brick have been reduced from 66 varieties to the following seven (all dimensions in inches): Plain wire-cut, 3x4x8½; plain wire-cut, 3½x4x8½; repressed lug, 3½x4x8½; wire-cut lug, 3½x4x8½; wire-cut lug, 3½x3½x8½; wire-cut lug, 3½x3x8½; repressed hillside, 3½x4x8½.

Standard Sizes of Building Brick

The standard size of common and face brick in this country is 2¼x3¾x8 inches.

GOVERNMENT STATISTICS

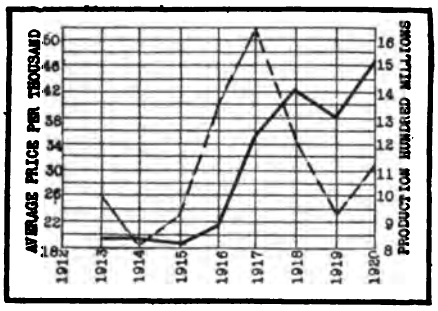
Sand Lime Brick Output in 1919 and 1920

	1919	1920	Percentage gained 1920 over 1919
Gross output	146,947,000	169,761,000	16
Gross value	$1,705,163	$2,490,283	46
Average price per thousand	$11.60	$14.67	26.5

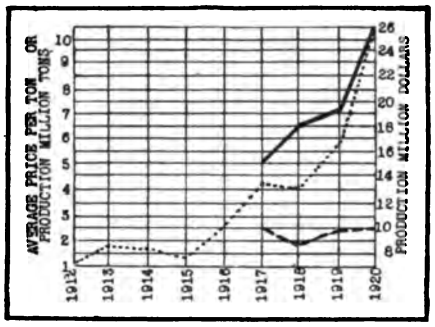
Clay Products Output in the United States in 1919 and 1920

	1919 (Estimated)	1920 (Estimated)	Approximate Increase or Decrease in 1920: Quantity or Value	Per Cent.
Common Brick:				
Quantity (thousands)	4,552,667	4,709,000	+ 156,333	+ 3
Value	$58,220,000	$81,330,000	+ $23,110,000	+ 40
Average price per thousand	$12.79	$17.27	+ $4.84	+ 35
Face Brick:				
Quantity (thousands)	778,190	728,000	— 50,190	— 6
Value	$15,240,000	$19,050,000	+ $3,810,000	+ 25
Average price per thousand	$19.58	$26.18	+ $6.60	+ 34
Enameled brick	$640,000	$820,000	+ $180,000	+ 28
Fancy or ornamental brick	$40,000	$30,000	— $10,000	— 25
Hollow Building Tile or Block:				
Quantity (tons)	2,310,450	2,457,000	+ 146,550	+ 6
Value	$16,620,000	$25,900,000	+ $9,280,000	+ 56
Average price per ton	$7.19	$10.54	+ $3.35	+ 47
Tile (not drain)	$7,250,000	$10,930,000	+ $3,680,000	+ 51
Architectural terra cotta	$4,840,000	$9,480,000	+ $4,640,000	+ 96
Vitrified brick or block:				
Quantity (thousands)	485,139	442,000	— 43,139	— 9
Value	$11,210,000	$12,020,000	+ $810,000	+ 7
Average price per thousand	$23.11	$27.17	+ $4.06	+ 18
Sewer pipe	$16,170,000	$22,240,000	+ $6,070,000	+ 38
Drain tile	$10,420,000	$13,080,000	+ $2,660,000	+ 26
Fire Brick:				
Quantity (thousands)	943,942	1,131,000	+ 187,058	+ 20
Value	$36,170,000	$52,750,000	+ $16,580,000	+ 46
Average price per thousand	$38.32	$46.64	+ $8.32	+ 22
Stove Lining	$730,000	$890,000	+ $160,000	+ 22
Miscellaneous	$7,100,000	$10,000,000	+ $2,900,000	+ 41
Total brick and tile	$184,650,000	$258,520,000	+ $73,870,000	+ 40
Total Pottery	$76,140,000	$105,700,000	+ $29,560,000	+ 39
Grand Total	$260,790,000	$364,220,000	+$103,430,000	+ 40

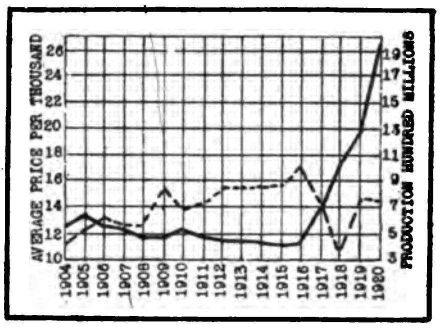
Comparative Charts



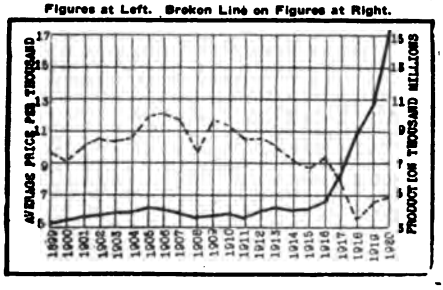
Production and Value of Fire Brick. Solid Line is Based on Figures at Left. Broken Line on Figures at Right.



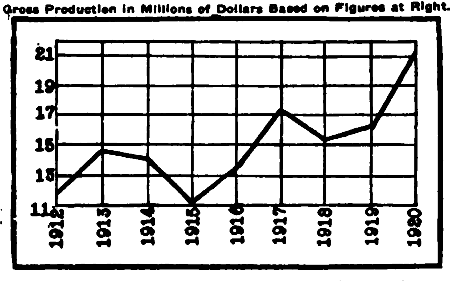
Hollow Building Tile. Solid Line Shows Average Price Based on Figures at Left. Broken or Dashed Line Shows Production of Million Tons Based on Figures at Left. The Dotted Line Shows Gross Production in Millions of Dollars Based on Figures at Right.



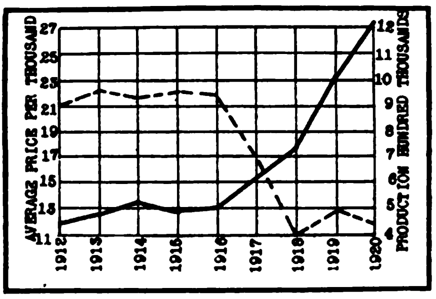
Production and Price of Face Brick. Solid Line is Based on Figures at Left, and Broken Line on Figures at Right.



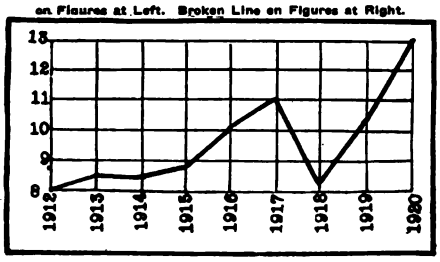
Production and Price of Common Brick. Solid Line is Based on Figures at Left. Broken Line on Figures at Right.



Sewer Pipe. Value of Gross Production in Millions of Dollars



Production and Value of Paving Brick. Solid Line is Based on Figures at Left. Broken Line on Figures at Right.



Drain Tile. Value of Gross Production in Millions of Dollars.

These Charts Show Production, Average Price and Gross Value of Some Heavy Clay Products.

Refractory Ore Output in 1919 and 1920

	1919	1920	Percentage Increase or Decrease 1919 and 1920
Magnesite, tonnage	156,226	303,767	+ 94
value	$1,248,415	$2,748,150	+ 120
Bauxite, tonnage	376,566	521,308	+ 28
value	$2,201,747	$3,247,345	+ 32.2
Chromite (chromic iron ore) tonnage	5,079	2,502	— 50.7
value	$129,302	$44,113	— 66

Pottery Products in 1919 and 1920

	1919 (estimated)	1920 (estimated)	Approximate increase or decrease in 1920 Amount	Pct.
Red earthenware	$ 1,160,000	$ 1,385,000	+$ 225,000	+19
Red and brown white-lined cooking ware	750,000	700,000	— 50,000	— 7
Stoneware	4,785,000	6,025,000	+ 1,240,000	+26
Chemical stoneware	645,000	1,000,000	+ 355,000	+55
Chemical porcelain	180,000	90,000	— 90,000	—50
Whiteware	29,700,000	39,360,000	+ 9,660,000	+33
China	7,625,000	11,060,000	+ 3,435,000	+45
Sanitary ware	14,480,000	21,480,000	+ 7,000,000	+48
Porcelain electrical supplies	12,190,000	18,560,000	+ 6,370,000	+52
Miscellaneous	*4,625,000	+6,040,000	+ 1,415,000	+31
Total	$76,140,000	$105,700,000	+$29,560,000	+39

*Including art pottery, cracqule porcelain, doll heads, gas-burner tips, gas-mantle rings, hardware trimmings, heating porcelain, nursery ware, pins, stilts, and spurs for potters' use, porcelain thread guides, saggers, smoking pipes, soda fountain supplies, and turpentine cups.

+Including art pottery, cracqule porcelain, doll heads, earthenware, fittings for textile mills, gas and electric lighting and heating appliances, hardware trimmings, heating porcelain, lead pots, pins, stilts, and spurs for potters' use, porcelain caster cups and door knobs; potters' supplies, smoking pipes, and turpentine cups.

2—ACCOUNTING

The accompanying chart is very useful at inventory time. It is used when the number of brick or tile per cubic foot for each size is known or can be determined for use as a standard. When this average per cubic foot is known it is only necessary to measure the pile and multiply the number of cubic feet by the standard average for the particular size. The line drawn across the chart shows how to operate it. This line is drawn for a pile of 1,000 cubic feet when the standard average per cubic foot is 25. This shows on the second column that the pile contains 25,000 pieces.

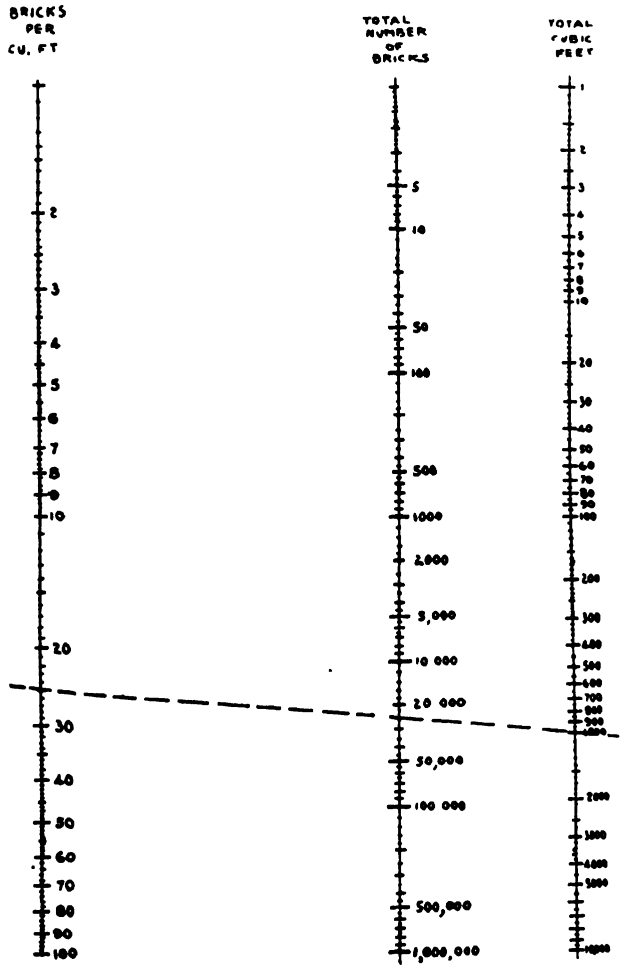


Chart for Determining Stock from Size of Pile

Definition of Important Valuation Terms

The following definitions of terms entering into accounting work are used by Arthur D. Little, Inc.:

Value. Means not only exchange value in dollars, but may properly be used to measure utility. The utility of such an unexchangeable article as the human hand is measured in dollars for the purposes of award or compensation. There can be but one correct amount for any particular value, but there may be several different values for the same commodity.

Fair Market Value. Is the amount of money which would induce a sale as between a willing seller and prudent purchaser; provided both seller and purchaser possess enlightened knowledge as to the particular commodity changing hands.

Service Value. As applied to clay deposits this term has somewhat the same meaning as "intrinsic value," excepting that it is a broader term and includes the extrinsic factor of availability. It therefore may be defined as the value due to quantity, quality, and location, irrespective of ownership or management. To use a marine expression, it is the "as is and where is" value. It exists regardless of earnings.

Going Value. Also known as "Going concern" or "Going concern value." It relates to establishment of earnings and may accrue in addition to and over-and-above "Service Value." The wise exploitation of a clay deposit for profit results in a certain going value accruing to such deposit thru actual monetary returns.

Popular Demand: Is used in its ordinary meaning. It is applicable to clay deposits on account of the insistence of the trade for certain recognized brands. For example, certain brick, tile and other clay products under trade names have become so popularized that proper consideration of this fact is essential to a fair valuation.

Economic Injury. Results when a portion of a valuable clay deposit is removed or depleted. Such economic injury is suffered irrespective of appreciated value due to enhanced real estate prices or other extrinsic influences. A valuable deposit of kaolin is "economically injured" thru depletion notwithstanding the fact that the building of a new railroad has enhanced the total value of the property. The value of the deposit itself has sustained depletion.

Mineral Rights. The Property interest of one who pays a periodical rental to the owner of the property for the privilege of quarrying or exploiting a deposit.

Mineral Fee. The ownership of the clay alone. It does not include fee title to the surface.

Depreciation. Means the gradual reduction in the value, of property due to physical deterioration, exhaustion, wear and tear thru use in trade or business.

Obsolescence. Means the gradual reduction in the value of property due to the normal progress of the art in which the property is used or to the property becoming inadequate to the growing needs of the trade or business. Obsolescence, a gradual lessening of value, must be distinguished from "loss of useful value," which contemplates an abrupt termination of usefulness.

Loss of Useful Value. Results when thru some change in business conditions the usefulness of the asset is suddenly terminated. Thus, the physical equipment of a mine or pit may lose its useful value thru the unexpected encountering of unfavorable geologic conditions.

Amortization. Applies particularly to those facilities constructed wholly or in part to produce articles for the prosecution of the great war. For example, a cotton mill constructed under war prices or built over-size in anticipation of long usefulness may be subject to amortization, wholly or in part. The term is also used to express the "writing off" of certain amounts over the useful life of the asset. For example, the amortization of the amount or bonus paid for a leasehold covering a definite period.

Depletion or Depreciation Allowed. Are the amounts allowed as deductions from gross income based upon the depletion or depreciation suffered during the taxable year.

Depletion or Depreciation Sustained. Are the amounts necessarily deducted from invested capital or cost on account of depleting or depreciating the clay deposit or physical property from date of acquisition. It is a recognition in audit of what actually happens.

Mineral Property or **"Property"** includes clay deposit, plant and equipment, development, and the surface value of the land. The value of a clay property is the sum of the values of its component parts.

Discovery. Is not applied to extensions of known deposits or ore bodies. It may be defined not only as a discovery of a new mine or deposit not previously known to exist, but the discovery of the true nature of a known deposit. The utility of a deposit may be discovered as well as its physical presence. For example, a deposit of "clay" or "dirt" may be discovered to be high grade Fuller's earth. There is no advantage in knowing that a deposit exists if ignorant of its true character.

How Much Can You Afford to Spend?

The question that is uppermost in the mind of every manager, superintendent or owner whenever any additions or improvements are contemplated on the plant, is "how much can we afford to spend for cost cutting equipment?"

In order to facilitate the arriving at an answer to such a question in any given case, the accompanying formula has been evolved. The use of this formula is especially applicable because of the general interest on this subject at the present time.

The formula is arrived at as follows:

Let A equal the number of days in the year that the plant usually operates, or the number of days that it is estimated it will operate. This item must be determined conservatively and some allowances made for possible shutdowns due to a shortage of business or accidents.

B equal the daily cost of labor and purchased material, such as coal, that will be saved by the new installation. This usually can be estimated rather closely.

C equal the daily saving that will be made on account of increased production.

D equal the daily saving on account of increased quality.

E equal any daily increase in cost of operation and labor, power materials, or repairs over the cost of the same operation at present.

F equal the interest rate that would annually be paid if the money for the expenditure were borrowed. Even if the money is not borrowed, it is very essential that an interest rate be figured.

G equal the annual depreciation of the contemplated equipment.

H equal the annual obsolescence of the equipment.

J equal the present scrap value of any equipment that will be discarded.

K equal the maximum expenditure that is advisable.

L equal the cost of the contemplated improvement or addition installed.

M equal the interest return that can be expected when the improvement is in operation.

Of course in advance of the installation nearly all figures are estimates, but most of them can be arrived at very closely. F, G, H and M are all written in percentages such as .06, .10, .25 and so forth.

To arrive at the investment possible in any given case, use the formula:

$$K = A \times \frac{B+C+D-E}{F+G+H} + J$$

To arrive at the possible return on the contemplated investment, use the following formula:

$$M = A \times \frac{B+C+D-E}{L-J} - (G+H)$$

In this formula the sum of G and H should be subtracted. It seems that there ought to be one other point considered, that is, the ability of the improvement to render unnecessary some expenditure of additional capital. For instance, the installation of any equipment that will turn the kilns faster will make it unnecessary to build more kilns for increased capacity. The formulae take care of this apparent advantage in favor of the improvement by considering the savings or profits in reduced costs, increased production or better quality, and therefore it is thought that any consideration of the ability to render the use of additional capital has been covered.

Considering the first formula, suppose that we wish to replace an old stack of a down-draft kiln with a new one. because results from the kiln have not been satisfactory.

Let A equal 200.

B is hard to figure, but suppose that every time this kiln is burned there will be a saving of One Dollar in labor and One Dollar in fuel, and that the kiln is burned on an average of 20 working days. This would make B equal to 10 cents.

We will omit any consideration of C because it is doubtful if the improvement would increase the production sufficiently to take it into account.

D might be estimated as One Dollar, which would amount to $20 a burn. The draft has been poor with the old stack, and the dampness gathering on the lower courses of the setting has caused a large loss due both to the softening of some and the scumming of other brick.

E will amount to nothing in this case.

F can be considered equal to .06.

G is estimated equal to .05 because the stack ought to last 20 years. However, the kiln has been in use for several years, and we must figure that the kiln and stack will be of no further use after six years, for we contemplate enlargements that will occupy the present location of the kiln and stack.

H is therefore equal to .12.

Suppose that we consider that the brick from the old stack will be worth $300, we use that figure for J.

Our formula therefore becomes:

$$K = 200 \times \frac{.10+1}{.06+.05+.12} + 300 = \$1{,}260$$

If, therefore, the stack cannot be built for $1,260, the improvement would entail a loss rather than a saving. We have shown this close a comparison purposely. As a matter of fact the large majority of cost cutting improvements that can be made in clay products manufacture show a value K according to the formula used often as large as 10 and even 30 times the contemplated cost.

The second formula will often show a return of 15 and even 30 per cent. on an investment.

E will be used in cases like the installation of motor trucks, where the cost of oil or gasoline was not encountered before, or in the case of a digging machine where no power was used formerly.

There is another point that might affect the advisability of making an improvement. Suppose that this kiln stack had been blown down by a storm or struck by lightning so that the kiln could not be used without a stack. Suppose that the stack would cost $1,500. In this case there is the additional benefit to be derived from the contemplated improvement of the saving in the interest, depreciation and obsolescence of the value of the kiln. Suppose that the kiln cost $5,000 and that the interest, depreciation and obsolescence amount to the same as the values for F, G and H as above, namely 23 per cent. The value of these items in dollars and cents will then be $1,150 annually. This makes the allowable investment equal $2,410.

25—AUTOMOBILE TRUCKS

The highest speed at which automobile trucks should operate in order to prevent undue wear and depreciation is as follows:

	Miles per hour		Miles per hour
¾ ton	18 to 20	3½ ton	12 to 14
1 ton	18 to 20	4 ton	10 to 12
1½ ton	16 to 18	5 ton	8 to 10
2 ton	14 to 16	6 ton	8 to 10
2½ ton	12 to 14	7 ton	8 to 10
3 ton	12 to 14	Tractors	8

41—BELT DRESSINGS

Leather

A good dressing is an application of luke-warm neatsfoot oil to both sides of a cleaned leather belt. If possible the oil should be allowed to stay on the belt for ten or twelve hours before the surplus is rubbed off. This treatment should be applied to a new leather belt several times a month.

Another good dressing consists of melting two pounds of edible beef tallow and after it has cooled slightly adding one pound of cod liver oil, stirring the mixture in one direction until cold.

Rubber

Castor oil if not used in excess is an excellent dressing for rubber belts.

Canvas

A light application of castor or raw linseed oil is good.

To Determine the Cost of Belt Slip per Year

To compute the percentage of slip in your belts, use this formula:

$$100 - \frac{100\ n\ (d+t)}{N\ (D+t)}$$

where

n=r.p.m. of the driven pulley

N=r.p.m. of the driving pulley.

d=diameter in inches of the driven pulley.

D=diameter in inches of the driving pulley.

t=thickness of the belt in inches.

If your belts are transmitting full power, no matter how carefully you are attending to them, you will always get an answer to the problem, due to the elasticity of the belt.

However, if the answer falls within two per cent. you can consider your belts in good condition as far as slip is concerned. But if the result is much greater than two per cent there is something wrong—the slip is excessive and may be very expensive, consuming power, as it does, year in and year out.

To compute the cost of the excessive slip for one year, use this formula:

$$\text{Cost a year in dollars} = \left\{ 0.98 - \frac{n\ d+t)}{N\ (D+t)} \right\} P\ C\ H\ W$$

where

P=h.p. delivered by the engine to the driving pulley.
C=cost in dollars of one h.p. per hour.
H=running hours per day.
W=working days per year.

The amount of cost of avoidable belt slip per year is also shown by the accompanying chart. The lines connecting these scales show the working scheme. A line connecting the point for six per cent. slip with the point for coal at $4 per ton is extended until it intersects line C. A line is then drawn from this point to a point on scale E corresponding to the tonnage of coal burned per year. This line will intersect scale D at a point which shows the amount of cost of the belt slip per year, in this case about $160.

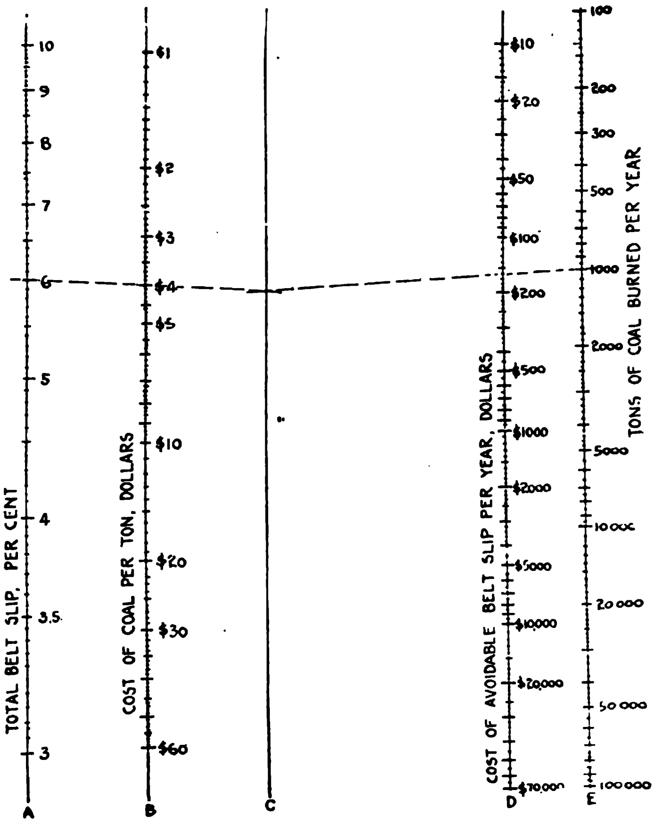


Chart to Determine Belt Slip

The per cent. of belt slip can be determined by finding the revolutions of the driving and of the driven shaft. A slippage of two per cent. is allowable and really cannot be avoided. In laying off per cent. of slip on scale A two per cent. should be deducted in order to arrive at avoidable belt slip.

67—BRICK, BUILDING

The following specifications are excerpts from the standard specifications and tests for building brick adopted by the American Society for Testing Materials.

The standard size of building brick shall be 2¼ by 3¾ by 8 in.

Sampling

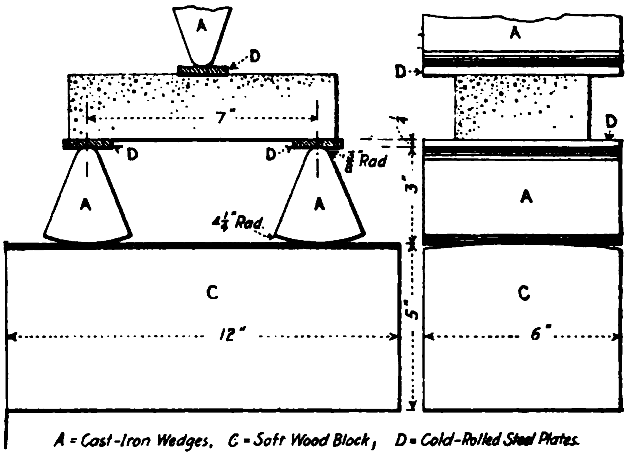
For the purpose of tests, brick shall be selected by an experienced person so as to represent the commercial product. All bricks shall be carefully examined and their condition noted before being subjected to any kind of test. For the purpose of the tests ten bricks will be required; they shall be thoroly dried to constant weight in a suitable oven at a temperature of from 225 deg. F. (107 deg. C.) to 250 deg. F. (121 deg. C.).

The absorption test is practically the same as the test described under that item in the definition section and the reader is referred therefore to Absorption.

Compression Test

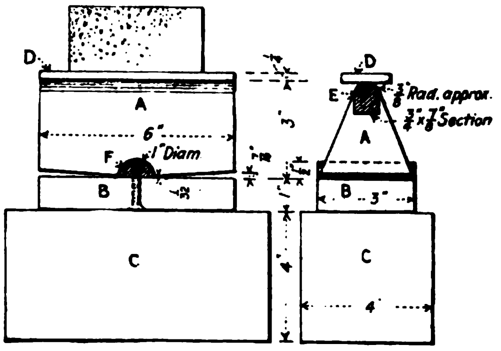
Compression tests shall be made on at least five half bricks, previously dried, each taken from a different brick. The half bricks shall be prepared either by sawing or cutting upon a yielding bed with a sharp mason's chisel, which shall be the full width of the brick. The specimens shall be tested on edge. To secure a uniform bearing in the testing machine the edge surfaces shall be bedded in a thin coat of plaster of Paris spread upon plate glass previously coated with a film of oil. Before applying the plaster of Paris, the bearing surface of the brick shall receive a coating of shellac. The brick shall be pressed firmly upon the surface, making the layer as thin as possible, and remain undisturbed until set. The depression of recessed or paneled bricks shall be filled with neat Portland-cement mortar, which shall stand at least 24 hours before testing.

The machine used for the compression tests shall be equipped with a spherical bearing block kept thoroly lubricated to insure accurate adjustment, which should be made by hand under a small initial load. During the test the beam of the testing machine shall be kept constantly in a floating position.



A = Cast-Iron Wedges, C = Soft Wood Block, D = Cold-Rolled Steel Plates.

FIG. 1.



A, B = Cast-Iron Wedges; C = Soft Wood Block; D, E, F = Cold-Rolled Steel

FIG. 2.

The breaking load shall be divided by the area in compression and the results reported in pounds per square inch.

Transverse Test

At least five brick, previously dried, shall be tested, laid flat-wise, with a span of 7 in., and with the load applied at midspan. The knife edges shall be slightly curved in the direction of their length. Steel bearing plates, about ¼ in. thick by 1½ in. wide, may be placed between the knife edges and the brick. The use of a wooden base block, slightly rounded transversely across its top, upon which to rest the lower knife edges (see Fig. 1), or the form of lower knife edge shown in Fig.

2, is recommended. If the knife edges shown in Fig. 2. are used, they should rest upon smooth plane blocks of wood at least 2 in. thick.

The modulus of rupture shall be computed in pounds per square inch by the following formula:

$$R = \frac{3\,Wl}{2bd^2},$$

in which l = the distance between supports in inches, b = the breadth and d = depth of the brick in inches, and W = the load in pounds at which the brick failed.

In recording the results of the test the type of brick shall be defined, whether stiff mud, soft mud, dry pressed, repressed, sand lime or other types. It is recommended that the data obtained be recorded on a "Laboratory Record."

Classification of Bricks

According to the results of the physical tests, the brick shall be classified as vitrified, hard, medium and soft brick on the basis of the following requirements:

Name of Grade.	Absorption Limits, per cent.		Compressive Strength (on edge), lb. per sq. in.		Modulus of Rupture. lb. per sq. in.	
	Mean of 5 Tests.	Individual Maximum.	Mean of 5 Tests.	Individual Minimum.	Mean of 5 Tests.	Individual Minimum.
Vitrified Brick	5 or less	6 0	5000 or over	4000	1200 or over	800
Hard Brick....	5 to 12	15 0	3500 or over	2500	600 or over	400
Medium Brick	12 to 20	24.0	2000 or over	1500	450 or over	300
Soft Brick ...	20 or over	No limit	1000 or over	800	300 or over	200

The standing of any set of bricks shall be determined by that one of the three requirements in which it is lowest.

BRICK, SEWER

The following specifications are excerpts from the tentative specifications for clay sewer brick suggested by the American Society of Testing Materials.

These specifications cover four classes of clay brick intended to be used in drainage structures for the conveyance of sewage, industrial waste and storm water, as follows, the purposes for which they are intended to be especially suitable being indicated:

Class A Vitrified Brick, for the interior of structures where resistance to the abrasive action of velocities up to 18 ft. per sec. is required.

Class B Vitrified Brick, for the interior of structures where resistance to the abrasive action of velocities up to 12 ft. per sec. is required.

Hard Brick, for structures requiring imperviousness to internal and external pressures and resistance to the abrasive action of velocities up to 8 ft. per sec.

Medium Brick, for storm water conduits, where a high degree of imperviousness is not required and where abrasive action is due to low velocities only.

For definitions of the above classes, see Table I.

The consumer or purchaser shall specify the class or classes of brick to be supplied.

The acceptability of brick shall be determined (1) by the results of the chemical and physical tests hereinafter specified, and (2) by visual inspection, to determine whether the brick comply with the specifications as to dimensions, shape and freedom from visible defects.

The acceptance of brick as satisfactorily meeting one of these two general requirements shall not be construed as in any way waiving the other.

Materials

(a) Clay brick shall be manufactured from surface clay, fire clay or shale or a combination of these materials.

(b) By surface clay is meant an unstratified, unconsolidated, plastic, glacial or alluvial clay, laid down by the glacial ice sheet, or on the flood plains of rivers, during the present geological epoch.

(c) By fire clay is meant a stratified clay, usually buff-burning, usually less indurated than shales, with poorly marked cleavage, laid down prior to the present geological epoch.

(d) By shale is meant a stratified clay, usually red-burning, more or less indurated by heat or pressure, with well-marked cleavage, laid down prior to the present geological epoch.

(e) The material shall possess such physical and chemical properties that when molded into brick and subjected to a suitable temperature the product will be strong, durable and serviceable, free from objectionable defects and in compliance with these specifications and tests.

Size

Sewer brick shall be not less than 2¼ by 3¾ by 8 in. nor more than 2½ by 4 by 8½ in.; except that No. 1 vitrified brick may be 3 by 4 by 8½ in. but not more than 3½ by 4 by 8½ in.

Chemical Tests and Requirements

The brick shall be dried to constant weight in a suitable oven at a temperature of from 225 to 250 deg. F. (107 to 121 deg. C.). The consumer or purchaser may prescribe in advance special chemical requirements in cases where sewage, industrial wastes or ground waters have a marked acid or alkaline character or are of abnormally high temperatures. He may make use of chemical analyses of the brick or brick materials to detect deleterious materials such as caustic lime, iron pyrites or any other materials which are known to cause slaking or disintegration. Such deleterious matter contained in the brick material shall be cause for rejection.

The specifications of the absorption test are practically the same as described under the definition section entry of Absorption.

TABLE I.—PHYSICAL TEST REQUIREMENTS FOR DIFFERENT CLASSES OF BRICK

Class.	Absorption Limits, per cent.		Compressive Strength (on edge), lb. per sq. in.		Modulus of Rupture, lb. per sq. in.	
	Mean of 5 Tests.	Individual Maximum.	Mean of 5 Tests.	Individual Minimum.	Mean of 5 Tests.	Individual Minimum.
Class A Vitrified	3 or less		5000 or over		1200 or over	
Class B Vitrified	5 or less	6 0	5000 "	4000	1200 "	800
Hard	5 to 10	12 0	3500 "	2500	600 "	600
Medium.........	10 to 15	17.0	2000 "	1500	450 "	300

The specifications for the compression and transverse tests and for the modulus of rupture are the same as for Brick, building.

Visual Inspection

All brick shall be given a thoro visual inspection at the sewer trench by a competent inspector employed by the purchaser to determine whether the brick, independently of the chemical and physical requirements, comply with the specifications of general properties as follows:

Brick shall be of rectangular cross-section, full size and of uniform dimensions thruout. Recessed brick shall not be accepted.

Brick shall have straight, parallel edges and square corners. The ends and at least one edge shall have a smooth plane surface; kiln marks not exceeding 1/16 inch in depth shall be permitted on the opposite edge.

Brick shall be thoroly and uniformly burned and when broken shall show a fracture of uniform and compact texture.

The color of the brick shall be considered to indicate their burning, providing the meaning of the variation in color be first determined from an investigation of the materials and the process of manufacture.

Brick shall be free from checks or cracks extending into the body of the brick in a manner that would affect their serviceability or strength. Brick shall be free from stones, pebbles, and visible grains or masses of lime.

Brick when struck together or when struck with a trowel shall give a clear ringing sound.

72—BRICK PAVING

The following specifications for paving brick are excerpts from the standard specifications of the American Society for Testing Materials.

The quality and acceptability of paving brick, in the absence of other special tests mutually agreed upon in advance by the seller on the one side and the buyer on the other side shall be determined by the following procedure:

I. The Rattler Test, for the purpose of determining whether the material as a whole possesses to a sufficient degree strength, toughness and hardness.

II. Visual Inspection, for the purpose of determining whether the physical properties of the material as to dimensions, accuracy and uniformity of shape and color, are in general satisfactory, and for the purpose of culling out from the shipment individually imperfect or unsatisfactory brick.

The acceptance of paving brick as satisfactorily meeting one of these tests shall not be construed as in any way waiving the other.

The Rattler Test

Place of Sampling.—In general, where a shipment of brick involving a quantity of less than 100,000 is under consideration, the sampling may be done either at the brick factory prior to shipment, or on cars at their destination or on the street, when delivered ready for use. When the quantity under consideration exceeds 100,000 the sampling shall be done at the factory prior to shipment. Brick accepted as the result of test prior to shipment, shall not be liable to subsequent rejection as a whole, but are subject to such culling as is provided for under Visual Inspection.

Method of Selecting Samples.—In general, the buyer shall select his own samples from the material which the seller proposes to furnish. The seller shall have the right to be present during the selection of a sample. The sampler shall endeavor, to the best of his judgment, to select brick representing the average of the lot. No samples shall include brick which would be rejected by visual inspection as provided in Part II, except that where controversy arises, whole tests may be selected to determine the admissibility of certain types or portions of the lot having a characteristic appearance in common. In cases where prolonged controversy occurs between buyer and seller and samples selected by each party fail to show reasonable concurrence, then both parties shall unite in the selection of a disinterested person to select the samples, and both parties shall be bound by the results of samples thus selected.

Number of Samples per Lot.—In general, one sample of ten brick shall be tested for every 10,000 brick contained in the lot under consideration; but where the total quantity exceeds 100,000, the number of samples tested may be fewer than one per 10,000, provided that they shall be distributed as uniformly as practicable over the entire lot.

Shipment of Samples.—Samples which must be transported long distances by freight or express shall be carefully put up in packages holding not more than 12 brick each. When more than six brick are shipped in one package, it shall be so arranged as to carry two parallel rows of brick side by side, and these rows shall be separated by a partition. In event of some of the brick being cracked or broken in transit, the sample shall be disqualified if there are not remaining ten sound undamaged brick.

Storage and Care of Samples.—Samples shall be carefully handled to avoid breakage or injury. They shall be kept in the dry so far as practicable. If wet when received, or known to have been immersed or subjected to recent prolonged wetting, they shall be dried for at least six hours in a temperature of 100 deg. F. before testing.

The Abrasive Charge.—The abrasive in the rattler charge shall consist of cast-iron spheres of two sizes. When new, the larger spheres shall be 3.75 in. in diameter and shall weigh approximately 7.5 lb. (3.40 kg.) each. Ten spheres of this size shall be used.

These shall be weighed separately after each ten tests, and if the weight of any large sphere falls to seven lb. (3.175 kg.) it shall be discarded and a new one substituted; provided, however, that all of the large spheres shall not be discarded and substituted by new ones at any single time, and that so far as possible the large spheres shall compose a graduated series in various stages of wear.

When new, the smaller spheres shall be 1.875 in. in diameter and shall weigh approximately 0.95 lb. (0.43 kg.) each. In general, the number of small spheres in a charge shall not fall below 245 nor exceed 260. The collective weight of the large and small spheres shall be as nearly 300 lb. as possible. No small sphere shall be retained in use after it has been worn down so that it will pass a circular hole 1.75 in. in diameter, drilled in an iron plate one-fourth in. in thickness, or weigh less than 0.75 lb. (0.34 kg.). Further, the small spheres shall be tested, by passing them over the above plate or by weighing after every ten tests, and which pass thru or fall below the specified weight, shall be replaced by new spheres; provided, further, that all of the small spheres shall not be rejected and replaced by new ones at any one time, and that so far as possible the small spheres shall compose a graduated series in various stages of wear. At any time that any sphere is found to be broken or defective it shall at once be replaced.

The iron composing these spheres shall have a chemical composition within the following limits:

Combined carbon	not under 2.50 per cent.
Graphitic carbon	not over 0.25 per cent.
Silicon	not over 1.00 per cent.
Manganese	not over 0.50 per cent.
Phosphorus	not over 0.25 per cent.
Sulphur	not over 0.08 per cent.

For each new batch of spheres used, the chemical analysis shall be furnished by the maker or be obtained by the user, before introducing into the charge, and unless the analysis meets the above specifications, the batch of spheres shall be rejected.

The Operation of the Test

The Brick Charge.—The number of brick per test shall be ten for all brick of so-called "block-size," whose dimensions fall between eight and nine in. in length, three and 3¾ in. in breadth, and 3¾ and 4¼ in. in thickness. Where brick of larger or smaller sizes than the dimensions given for blocks are to be tested, the same number of brick per charge should be used, but allowance for the difference in size should be made in setting the limits for average and maximum rattler loss. No brick should be selected as part of a regular test that would be rejected by any other requirements of the specifications under which the purchase is made.

Speed and Duration of Revolution.—The rattler shall be rotated at a uniform rate of not less than 29.5 nor more than 30.5 revolutions per minute, and 1,800 revolutions shall constitute the test. A counting machine shall be attached to the rattler for counting the revolutions. A margin not to exceed ten revolutions will be allowed for stopping. Only one start and stop per test is generally acceptable. If, from accidental causes, the rattler is stopped and started more than once during a test, and the loss exceeds the maximum permissible under the specifications, the test shall be disqualified and another made.

The Scales.—The scales must have a capacity of not less than 300 lb. and must be sensitive to 0.5 oz., and must be tested by a standard test weight at intervals of not less than every ten tests.

The Results.—The loss shall be calculated in percentage of the initial weight of the brick composing the charge. In weighing the rattled brick, any piece weighing less than one lb. shall be rejected.

The Records.—A complete and continuous record shall be kept of the operation of all rattlers working under these specifications. This record shall contain the following data concerning each test made:

1. The name of the person, firm or corporation furnishing each sample tested.
2. The name of the maker of the brick represented in each sample tested.
3. The name of the street, or contract, which the sample represented.
4. The brands or marks upon the brick by which they were identified.
5. The number of brick furnished.
6. The date on which they were received for test.
7. The date on which they were tested.
8. The drying treatment given before testing, if any.
9. The length, breadth and thickness of the brick.
10. The collective weight of the ten large spherical shot used in making the test at the time of their last standardization.
11. The number and collective weight of the small spherical shot used in making the test, at the time of their last standardization.
12. The total weight of the shot charge, after its last standardization.
13. Certificate of the operator that he examined the condition of the machine as to staves, liners, and any other parts affecting the barrel, and found them right at the beginning of the test.
14. Certificates of the operator of the number of charges tested since the last standardization of shot charge and last renewals of stave liners.
15. The time of the beginning and ending of each test, and the number of revolutions made by the barrel during the test, as shown by the indicator.
16. Certificate of the operator as to number of stops and starts made in each test.
17. The initial collective weight of the ten brick composing the charge and their collective weight after rattling.
18. The loss calculated in percentage of the initial weight; and the calculation itself.
19. The number of broken brick and remarks upon the portions which were included in the final weighing.
20. General remarks upon the test and any irregularities occurring in its execution.
21. The date upon which the test was made.
22. The location of the rattler and name of the owner, upon which the test was made.
23. The certificate of the operator that the test was made under the specifications of the American Society for Testing Materials and that the record is a true record.
24. The signature of the operator or person responsible for the test.
25. The serial number of the test.

Acceptance and Rejection of Material

Basis of Acceptance or Rejection.—Paving brick shall not be judged for acceptance or rejection by the results of individual tests, but by the average of no less than five tests. Where a lot of brick fail to meet the required average, it shall be optional with the buyer whether the brick shall be definitely rejected or whether they may be regraded and a portion selected for further test.

Range of Fluctuation.—Some fluctuation in the results of the rattler test, both on account of variations in the brick and in the machine used in testing, are unavoidable, and a reasonable allowance for such fluctuations should be made, wherever the standard may be fixed.

In any lot of paving brick, if the loss on a test computed upon its initial weight exceeds the standard loss by more than two per cent., then the portion of the lot represented by that test shall at once be resampled and three more tests executed upon it, and if any of these three tests shall again exceed by more than two per cent. the required standard, then that portion of the lot shall be rejected.

If, in any lot of brick, two or more tests exceed the permissible maximum, then the buyer may at his option reject the entire lot, even tho the average of all the tests executed may be within the required limits.

Fixing of Standards.—The percentage of loss which may be taken as the standard, will not be fixed in these specifications, and shall remain within the province of the contracting parties. For the information of the public, the following scale of average losses is given, representing what may be expected of tests executed under the foregoing specifications:

	General Average Loss Per Cent.	Maximum Permissible Loss Per Cent.
For brick suitable for heavy traffic	22	24
For brick suitable for medium traffic	24	26
For brick suitable for light traffic	26	28

Which of these grades should be specified in any given district and for any given purpose is a matter wholly within the province of the buyer, and should be governed by the kind and amount of traffic to be carried, and the quality of paving brick available.

Culling and Retesting.—Where a lot or portion of a lot of brick is rejected, either by reason of failure to show a low enough average test or because of tests above the permissible maximum, the buyer may at his option permit the seller to regrade the rejected brick, separating out that portion which he considers at fault and retaining that which he considers good. When the regrading is complete, the good portion shall be then resampled and retested, under the original conditions, and if it fails again either in average or in permissible maximum, then the buyer may definitely and finally reject the entire lot or portion under test.

Payment of Cost of Testing.—Unless otherwise specified, the cost of testing the material as delivered or prepared for delivery, up to the prescribed number of tests for valid acceptance or rejection of the lot, shall be paid by the buyer. The cost of testing extra samples made necessary by the failure of the whole lot or any portion of it, shall be paid by the seller, whether the material is finally accepted or rejected.

Visual Inspection

It shall be the right of the buyer to inspect the brick, subsequent to their delivery at the place of use, and prior to or during laying, to cull out and reject upon the following grounds:

All brick which are broken in two or chipped in such a manner that neither wearing surface remains substantially intact, or that the lower or bearing surface is reduced in area by more than one-fifth. Where brick are rejected upon this ground, it shall be the duty of the purchaser to use them so far as practicable in obtaining the necessary half-brick for breaking courses and making closures, instead of breaking otherwise whole and sound brick for this purpose.

All brick which are cracked in such a degree as to produce defects such as are defined above, either from shocks received in shipment and handling, or from defective conditions of manufacture, especially in drying, burning or cooling, unless such cracks are plainly superficial and not such as to perceptibly weaken the resistance of the brick to its conditions of use.

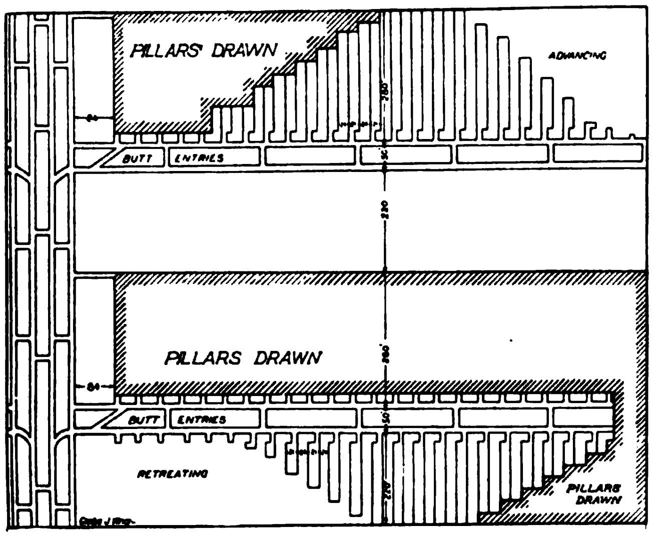
All brick which are so off-size, or so misshapen, bent, twisted or kiln-marked, that they will not form a proper surface as defined by the paving specifications, or align with other brick without making joints other than those permitted in the paving specifications.

All brick which are obviously too soft and too poorly vitrified to endure street wear. When any disagreement arises between buyer and seller under this item it shall be the right of the buyer to make two or more rattler tests of the brick which he wishes to exclude, and if in either or both tests, the brick fall beyond the maximum rattler losses permitted under the specifications, then all brick having the same objectionable appearance may be excluded, and the seller shall pay for the cost of the test. But if under such procedure, the brick which have been tested as objectionable, shall pass the rattler test, both tests falling within the permitted maximum, then the buyer cannot exclude the class of material represented by this test and he shall pay for the cost of the test.

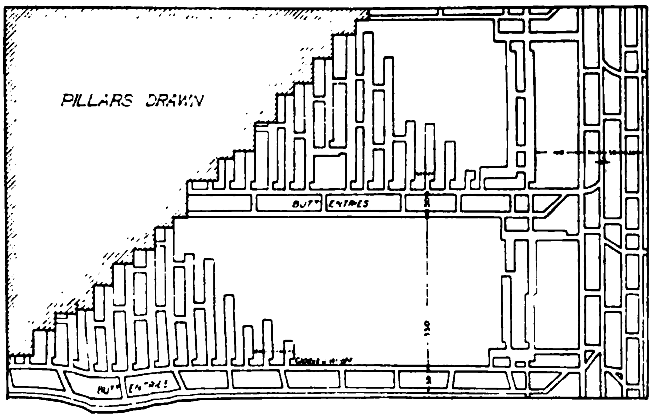
All brick which differ so markedly in color from the type or average of the shipment, as to make the resultant pavement checkered or disagreeably mottled in appearance. This section shall not be held to apply to the normal variations in color which may occur in the product of one plant among brick which will meet the rattler test as referred to under Acceptance and Rejection of Material, but shall apply only to differences of color which imply differences in the material of which the brick are made, or extreme differences in manufacture.

134—CLAY WINNING

The Coal Review in October, 1921, contained a very good description of the method used in operating a coal mine by the room and entry system. On account of the same method being applicable to a fire clay mine when it is desired to mine all of the clay we reproduce it here.



Half Advance and Half Retreat Method of Mining.



Full Retreat Method of Mining

Of course this method is not applicable where it is necessary to keep the surface land in its original condition, as some of the pillars must be left in place in that case to hold the roof.

115—CHAIN DRIVE, SPROCKET

Always operate a chain-belt with the back of the coupling hook to the wheel, as in Fig. 1.

The usual instructions are to run hook first on drives and bar first on elevators and conveyors.

When considering the relative merits of different methods of running chain-belt drives, the drive should be considered as a whole, and the action noted at four points, viz.: a, entering point on the DriveR; b, releasing point on the DriveR; c, entering point on the DriveN; d, releasing point on the DriveN; as shown by a, b, c, d, in Fig. 1.

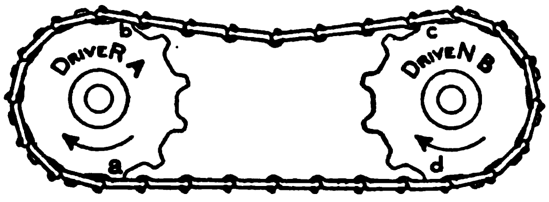


Fig. 1

a—entering point on DriveR
b—releasing point on DriveR
c—entering point on DriveN
d—releasing point on DriveN

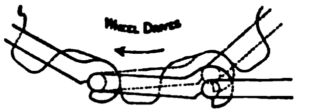


Fig. 2
Action good: dotted lines show position of the link after bending. All the wear is internal—that is, on the inside of the Hook.

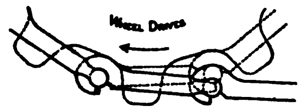


Fig. 3
Action bad: dotted lines show position of the link after bending. Wear on outside and inside of Hook and on the Sprocket.

In this discussion, the action at a point is said to be good when all the articulation or bending takes place in the joint of the links, Fig. 2. The action is said to be bad when, in bending, the link rubs on the sprocket, producing wear on the sprocket and outside or external wear on the hook, Fig. 3.

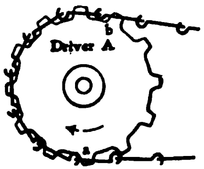


Fig. 4
Wheel pitch smaller than pitch of Link-Belt. Entering tooth a does all the work.

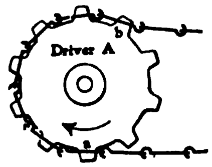


Fig. 5
Wheel pitch larger than pitch of Link-Belt. Releasing tooth b does all the work.

Another fact is also to be remembered: there is never more than one tooth in action at any one time. No matter how carefully the chain-belt and sprocket may be made, as soon as the load comes on, there is a change caused by stretch and wear.

We can pre-determine which tooth shall be in action by making the pitch of the wheel either larger or smaller than the pitch of the chain-belt. Thus, on the DriveR, Fig. 4, the wheel pitch being smaller than the pitch of the chain-belt, the entering tooth does all the work. In Fig. 5 the conditions are reversed: the wheel pitch is the larger and the releasing tooth does the work. On the DriveN the same thing holds, except that here conditions are reversed.

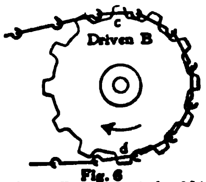


Fig. 6
Wheel pitch smaller than pitch of Link-Belt. Releasing tooth d does all the work.

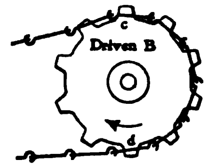


Fig. 7
Wheel pitch larger than pitch of Link-Belt. Entering tooth c does all the work.

When the wheel pitch is smaller than the link pitch, the releasing tooth does the work, Fig. 6. When the wheel pitch is larger than the link pitch, the entering tooth does all the work, Fig. 7.

For the best work the pitch of the DriveR should be larger than the pitch of the chain-belt, see Fig. 5, and the pitch of the DriveN should be smaller than that of the chain-belt, as in Fig. 6. The releasing teeth, b and d, are, therefore, the working teeth, and the chain-belt can seat at a and c quietly and take the load gradually as the wheel revolves.

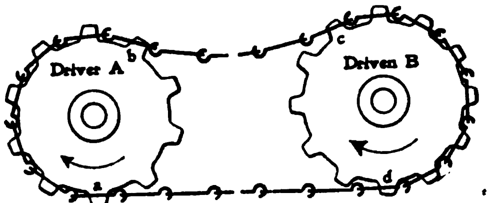


Fig. 8
Pitch of DriveR large, of DriveN small. Link runs Bar first.
Action at a good. Action at b bad. Action at c good. Action at d bad.
Two (2) bad points.

Having considered the question of wheels, we will now regard the drive as a whole to determine whether the chain-belt shall be run bar first or hook first.

In Fig. 8 we have the DriveR large, the DriveN small; hence, b and d are the teeth in action. This drive runs bar first; action at a good, at b bad; at c good, at d bad.

In Fig. 9 we have the same sprockets as in Fig. 8, but the drive runs hook first. Here the action at a is bad, but the fact that the hook is not in contact with a tooth face at this point makes the consequent wear of little extent. The action at b is good. The action at c is bad, but this is on the slack side of the chain-belt and this bad action causes no wear. The action at d is good.

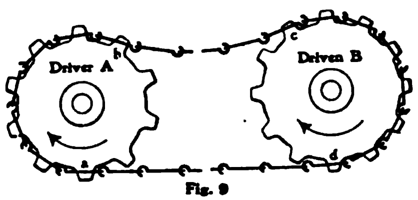


Fig. 9
Pitch of DriveR large, of DriveN small. Link runs Hook first.
Action at a bad. Action at b good. Action at c not objectionable. Action at d good.
One (1) bad point—therefore, run Hook first.

It is thus seen that there are two very bad points (b and d) where the drive runs bar first, and only one serious trouble (a) when running hook first. Therefore, run hook first.

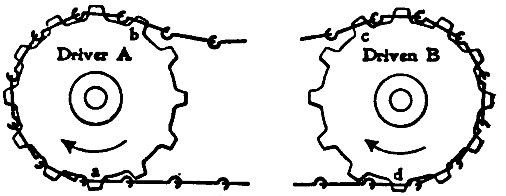


Fig. 10
Pitch of DriveR small, of DriveN small. Link runs Bar first.
Action at a good. Action b bad, but not objectionable. Action at c good.
Action at d bad.

Consider a drive when the sprockets are such as are usually furnished: these are ground to fit the new chain-belt; when the latter stretches, both DriveR and DriveN are small as compared to it, and teeth a and d are now in action.

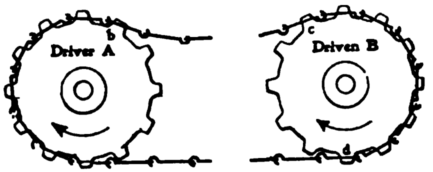


Fig. 11
Pitch of DriveR small, of DriveN small. Link runs Hook first.
Action at a bad. Action at b good. Action at c not objectionable. Action at d good.

In Fig. 10 we have such a pair of wheels with the link running bar first. The action at a is good; at b it is bad, but as there is no tension on the chain-belt at this point, this is not objectionable. At c the action is good; at d it is bad. In this case, therefore, it would seem that the wear would be confined to the DriveN wheel. This is so in actual practice.

In Fig. 10 the only wear is on DriveN, caused by the bad action at d. The operation forms a hook on d and eventually breaks a link.

Observe the same wheels with the chain-belt running hook first, Fig. 11. The action at a is bad; at b it is good; at c it is bad, but not objectionable, because, as before, there is no tension at this point; action at d is good. Thus all the wear would seem to be on the DriveR as a result of the action at a. This is found to be the case; hence, both theory and practice show that with the chain-belt running bar first, DriveN wheel wears; with chain-belt running hook first, DriveR wheel wears.

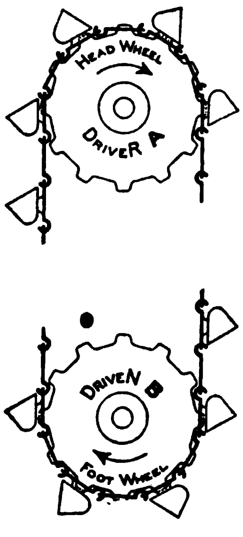


Fig. 12

Now, it is found that because the wear at d, running bar first, is caused by the drive slipping up the tooth, it tends to undercut and form a hook and thus break the chain-belt. On the other hand, the wear at a, when running hook first, is caused by the drive slipping down the tooth, and the wheel will wear out completely without endangering the chain-belt. It has also been proved that the DriveR, running back first, lasts several times as long as the DriveN wheel when running bar first. As the DriveN wheel is in nearly every case much larger than the DriveR, and the consequent wear on each tooth is less, it would seem that if the chain-belt were run so as to wear the DriveN, the wear on the two wheels would be equalized. This would be poor practice for the reason that the DriveR, being smaller, is more cheaply replaced, and the repair account will, therefore, be less running hook first.

In Fig. 11 the only wear is on DriveR, caused by the bad action at a. The chain wears evenly, does not form a hook at a, and not break. Therefore, run hook first in drives.

In elevators, Fig. 12, the head wheel acts as a DriveR, the foot wheel simply as an idler, because it is doing no work. Therefore, run the drive bar first so as to favor the DriveR.

In conveyors one wheel is always an idler, comparatively speaking, and the same reasoning holds as for elevators; the chain-belt should run bar first in all cases.

The foregoing remarks apply equally well to all closed-end pin type links: the closed end corresponds to the hook and the pin end to the bar, in the foregoing descriptions.

In general, therefore, on drives run hook first, and on elevators and conveyors run bar first.

Chain Drive Data

In transmitting power the engagement of each link with the tooth of the sprocket wheel is attended by a certain degree of shock, and as this is multiplied and intensified as the speed is increased, the working strength of sprocket chain drive should be reduced in a compensating ratio.

As the result of a long continued and carefully conducted series of tests, the Link-Belt Co. recommends that the working strength of chain drives be determined as follows:

For a speed of 200 F. P. M. and under, divide average ultimate strength by 6. For a speed of 300 F. P. M. and under, divide the same figure by 8. For 400 F. P. M. and under, divide by 10. For 500 F. P. M. and under, divide by 12. For 600 F. P. M. and under, divide by 16 and for 700 F. P. M. and under, divide by 20.

$$\text{Allowable h. p. of any chain} = \frac{\text{safe working load in pounds as found above} \times \text{chain speed in feet per minute}}{33{,}000}$$

Chain speed=sprocket diameter in feet×3.1416×rpm. of shaft.

The best speed for operating sprocket chain is 200 feet per minute. All sprockets should have more than eight teeth to avoid excessive wear. Use long pitch chains only for slow speeds and short pitch chains for high speeds. The medium pitch chain is the best under average conditions. Thin grease or heavy oil should be used for lubrication of sprocket drive chain.

Courtesy Link-Belt Co.

123—CHROME

The following, dealing specifically with Chrome is a continuation of the methods of analysis shown on pages 147 and 148 in item No. 133 Clay testing.

Chrome Ores and Chrome Brick

20. The sample shall be secured after manner of any of the approved methods of sampling. If from ores or chrome-bearing refractories, it shall not be less than 10 lb., in small nut-size particles when sent to the laboratory. If from chrome brick, the sample shall consist of a small portion from the interior of from 15 to 25 brick. This 10-lb. sample shall be crushed to pass a 20-mesh sieve and quartered until a sample of 100 g. is secured, which shall be ground to pass a 100-mesh sieve. From this portion, a smaller working sample shall be quartered and ground in an agate mortar to a very nearly gritless powder. In the case of hard burned brick or hard lump chrome ore the very fine grinding assists materially in solution of the sample.

21. Dry the fine, ground powder at 110 deg. C. for not less than one hour. Cool in desiccator. Fuse 0.5 g. of the thoroly dried sample in approximately 10 g. of fused potassium bi-sulfate in a platinum crucible. The usual cautions of a bi-sulfate fusion should be observed: that is, the flame turned very low so that the bi-sulfate just melts, increasing the flame so that the bi-sulfate remains in a liquid condition, very gradually increasing until the crucible reaches a dull red heat. The object of the slow heating is to retain the sulfuric acid, which is the effective part of the flux. The most refractory ores should be thoroly fused in 1½ to 2 hours. Remove the crucible from the burner and allow to cool in the air. The bi-sulfate melt will shrink from the crucible and may be removed easily in one cake. Dissolve the fusion in 200 cc. hot HCl (1:1), boiling until the solution acquires a clear, bright green color. Transfer the solution to a porcelain evaporating dish and evaporate to dryness on a water bath. Bake at exactly 120 deg. C. until free from hydrochloric acid fumes. Moisten with hot HCl (1:1), evaporate on water bath and bake a second time at 120 C. Dissolve in 200 cc. hot dilute HCl (1:1), and filter out the silica. Ignite and weigh the silica in a platinum crucible. Add two drops concentrated H_2SO_4 and sufficient HF to remove all silica. Evaporate, ignite and weigh. The difference gives the amount of silica present in the sample. Should there be any appreciable residue left in the crucible it should be fused with a small amount of fused $KHSO_4$ and added to the filtrate from the silica.

Dilute the filtrate from the silica to about 500 cc. and precipitate iron, aluminum, chromium and titanium, if present, with NH_4OH, using care to have not more than two drops of NH_4OH in excess in order to avoid solution of chromium and aluminum hydroxide in the alkaline solution. On account of the relatively large amount of magnesium that is usually present in chrome ores and chrome brick it is advisable to dissolve the precipitate in hot dilute HCl and precipitate a second time. Filter out the combined hydroxides and dissolve them on the filter paper with HNO_3, catching the solution in a porcelain casserole. Add a few crystals of $KClO_3$ and evaporate the nitric solution, adding a crystal of $KClO_3$ from time to time until the chromium is completely oxidized, which is indicated by a change from a dull green to a brilliant orange color. Dilute this solution with hot water and again precipitate with NH_4OH, filtering as before. The filtrate contains a large percentage of the chromium, while the residue on the filter consists of iron and aluminum hydroxides and titanium, if present. Repeat the oxidation two or three times until the filtrate from the iron and aluminum hydroxide precipitation shows no further traces of chromium. Concentrate and combine the filtrates containing chromium to approximately 500 cc. Add H_2SO_3 until the liquid changes from a bright orange to a brilliant green color and heat to boiling. Add NH_4OH to precipitate chromium as hydroxide, having not more than two drops in excess, as stated above. Filter, wash well with hot water, ignite and weigh as Cr_2O_3. The iron and aluminum and titanium hydroxides are ignited and weighed in a platinum crucible. Fuse the combined oxides with a small amount of $KHSO_4$, following the same precautions as mentioned above. Dissolve the fusion in dilute H_2SO_4, reduce with H_2S and titrate the iron with standard permanganate solution. Determine the titanium present by the colorimetric method, as described in Section 16. Subtract the combined amounts of Fe_2O_3 and TiO_2 from the total weight of the three oxides and thus determine Al_2O_3. If titanium is absent, reduce the iron with metallic zinc and titrate with K_2MnO_4, which is a little quicker method than the H_2S reduction.

To the combined filtrates from the precipitations of iron, aluminum, chromium and titanium hydroxides add bromine, allow to stand for a few minutes and then add sufficient NH_4OH to precipitate the manganese hydroxide. Boil to concentrate the manganese hydroxide if any be present. Filter, ignite and weigh as Mn_3O_4. In the filtrate from the manganese add NH_4OH and $(NH_4)_2C_2O_4$. Heat to boiling and when the calcium oxide has settled, filter with the usual precautions. The calcium oxide may be determined by ignition or by the volumetric method. (Refer to the determination of calcium oxide as described in Section 17.)

Evaporate the filtrate from the calcium oxalate to dryness with HNO_3 to remove the excess of ammonium salts. Dissolve the residue in hot water, filter, allow to cool and determine MgO as described in Section 18.

Determine alkalies by the J. Lawrence Smith Method, as described in Section 19.

Rapid Routine Method for the Analysis of Chrome Brick and Chrome Ore

22. The sample shall be secured after the manner of any of the approved methods of sampling. If from ores or chrome bearing refractories it shall not be less than 10 lb. in small nut-sized particles when sent to the laboratory. If from chrome brick, the sample shall consist of a small portion from the interior of from 15 to 25 brick. This 10-lb. sample shall be crushed to pass a 20-mesh sieve and quartered, until a 4-oz. sample is secured, which shall be ground to pass a 100-mesh sieve. From this portion a smaller working sample shall be quartered and ground in an agate mortar to a very nearly gritless powder. In the case of hard burned brick or hard lump chrome ore the very fine grinding assists materially in solution of the sample. Dry the fine, ground powder at 110 deg. C. for not less than 1 hour. Cool in desiccator.

Chromium

23. Fuse 0.5 g. of the sample in 8 to 10 g. of sodium peroxide in a nickel or porcelain crucible over a Bunsen burner, being careful not to heat too strongly. When fused, leach out with cold water, boil 15 minutes to decompose any sodium peroxide. Cool and add 100 cc. of H_2SO_4 (1:1). Cool to tap-water temperature and titrate with ferrous ammonium sulfate and potassium permanganate. Time 30 to 45 minutes.

Silica and Iron

24. Fuse 0.5 g. of the sample in a nickel crucible over a Bunsen burner. Leach out with cold water, make acid with HCl and evaporate to dryness. Take up with 200 cc. water and add 10 cc. HCl. Filter off silica and wash well with hot water and hot dilute HCl. For high silica a second evaporation is necessary. The filtrate or combined filtrate is made alkaline with sodium hydroxide and about 5 cc. of bromine added. The mass is allowed to digest for ½ hour on a steam bath. This oxidizes the iron and chromium, precipitates the iron and dissolves the chromium and aluminum. After precipitating the iron twice it is filtered off on an asbestos plug and washed well with hot water. This precipitate of iron may be dissolved off the plug with hot HCl (1:1) and determined by the stannous chloride reduction, and permanganate method.

A blank should be run in conjunction with this method and deductions made when necessary to determine the purity of the chemicals used.

128—CLAY PLANT LOCATION AND DESIGN

Factors to be Considered in Building a Plant

1. Demand. Basis of size of plant.
2. Selling prospects. Basis of size of plant.
3. Raw materials. Availability and quality. Quality of water is very important.
4. Shipping facilities. Raw materials, fuel, market.
5. Power.
6. Labor.
7. Shipping facilities are dependent to a great extent on the size of the plant.
8. Fuel, quality, price, quantity, availability, and dependability are important.
9. Railroad competition is a good factor.
10. Water shipments are good when available.
11. Availability and value of plant.
12. Topography of land.
13. Taxes.
14. Dust and smoke nuisance.

Building Data

For building higher than one story, Tyrell gives the following approximate costs in percentage for the same floor areas:

First story ....1·00 per cent.
Second story .... 92 per cent. additional.
Third story .... 87 per cent. additional.
Fourth story .... 86 per cent. additional.
Fifth story .... 85 per cent. additional.

This is caused partly because of the stronger walls that the lower floors must have in order to carry the upper floors.

See also statistical section of Kilns, Down-draft design and construction of.

84—BURNING, VITRIFICATION PERIOD OF

Temperatures Employed in Burning Clay Wares

		Cone	Temperature Range Deg. C.	Temperature Range Deg. F.	Usual Temperature
Common Brick	Surface Clay	013-08	860- 990	1600-1800	1800
	Shale	08-04	990-1070	1800-2000	1950
Face Brick	Shale	04- 4	1070-1210	1950-2200	2150
	Fire Clay	1- 7	1150-1270	2100-2300	2200
Paving Brick (Vitrified)		02- 5	1110-1230	2000-2250	2200
Fire Brick (Clay)		7-12	1270-1370	2300-2500	2450
Fire Brick (Silica)		17-19	1470-1510	2650-2750	2720
Chrome Brick		17-20	1470-1530	2650-2800	2770
Magnesite Brick		17-20	1470-1530	2650-2800	2770
Bauxite Brick		17-20	1470-1530	2650-2800	2770
Hollow Building Tile	Surface Clay	011-08	920- 990	1600-1800	1800
	Shale	08-04	990-1070	1800-2000	1950
Drain Tile		011-08	920- 990	1700-1800	1800
Sewer Pipe		2- 7	1170-1270	2030-2320	2300
Roofing Tile		04- 2	1070-1170	1960-2140	2080
Architectural Terra Cotta		01- 7	1130-1270	2070-2320	2300
Enamel Brick		1- 7	1150-1270	2100-2300	2300
Whiteware	Biscuit	7- 9	1270-1310	2320-2390	2370
	Glost	1- 4	1150-1210	2100-2210	2200
Sanitary Ware	Biscuit	8-10	1290-1330	2350-2430	2420
	Glost	3- 6	1190-1250	2170-2290	2275
Floor and Wall Tile		6- 7	1250-1270	2280-2320	2310
Electrical Porcelain		9-12	1310-1370	2390-2500	2470
Stoneware (Chemical)		17-18	1470-1490	2650-2700	2700

126—CLAY DEPOSITS, CLASSIFICATION OF

Classification of Clays Adapted From Edward Orton, Jr.

Group	Class	Sub-Class	Use
Primary. Formed on the spot where they now occur	1. Entirely decomposed igneous rock	A. White burning Kaolin or china clay	Whitewares
		B. Red burning	Brick and tile
	2. Partially decomposed igneous rock	A. White burning Cornwall Stone, etc.	Whitewares
		B. Red burning	Not used
Secondary or Transported	1. Deposited in still water	A. White burning Plastic kaolin	Whitewares
		Ball clays	Whitewares
		B. Stratified fire clays Highly refractory	Refractories
		Hard Flint	Refractories
		Plastic	Refractories
		Vitrifying or No. 2	Stone ware, sewer pipe, paving and building brick
		C. Shales Nearly pure Hard, Sandy, Soft, Calcareous, Ferruginous,	Roofing tile Common & face brick Common brick & drain tile Brick of all sorts, sewer pipe, tile
		Soft or Joint Clays; Bituminous.	Generally avoided
		D. Fine grained Alluvial clays	Brick and tile
		E. Bog or swamp clays	Seldom used
	2. Deposited from running water	A. Sandy clays	Brick and tile
		B. Clayey sands	Brick
	3. Deposited by glacial action	A. Boulder clay or till	Brick and tile
		B. Slip clays	Cheap glazes
	4. Deposited by wind	A. Loess	Brick and tile
	5. Residual clays left by the decomposition of secondary rocks	A. Refractory White burning	Whitewares, Example Missouri kaolin
		Buff burning	Refractories, Example Flint and plastic fire clays of Missouri
		B. Fusible	Seldom used

Classification of Clays Adapted from Orton and Wheeler

High Grade Clays	White Ware Clays	Kaolin China Clay Ball clay
	Refractory Clays	Plastic Fire Clay Flint Clay Refractory Shale
	Pottery Clays	
Low Grade Clays	Vitrifying Clays	Stone Ware Clay and Shales Paving Brick Clay and Shales Sewer Pipe Clay and Shales Roofing Tile Clay and Shales
	Brick Clays	Terra Cotta Clay and Shales Common Brick Clay and Shales Drain Tile Clay and Shales
	Gumbo Clays	
	Loess and Adobe Clays	
	Slip Clays	
	Fullers Earth	

From Rolfe, Illinois State Geological Survey. Bulletin No. 9.

132—CLAY, PROSPECTING FOR

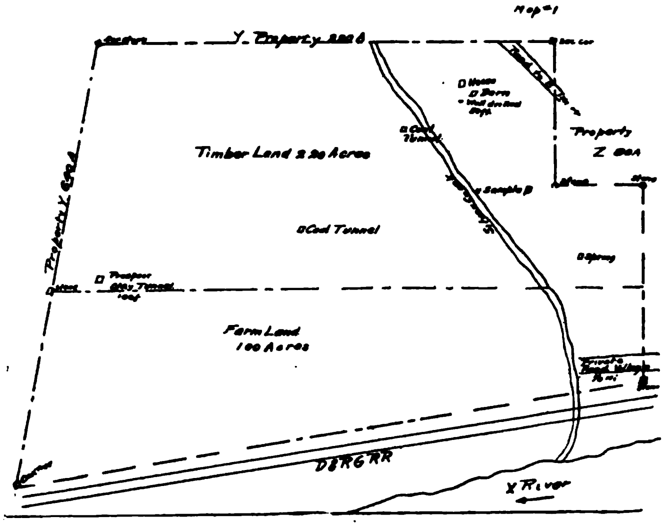
The work should be done in the following order:

Land Survey

This map should show all property lines, the locations of all buildings, streams, railway lines, shafts, first prospect holes, well springs, timber and the names of the adjoining property owners. The map should also show the connection with the nearest village and railroad.

Topographical Map

This map should show everything the first map shows and in addition should show all the elevations at ten foot intervals and on the flatter portions of the property should show all elevations at no less than five foot intervals. On this map should be placed the locations of all drill holes and all prospecting holés.



Map 1. Land Survey Map

Drilling or Prospect Holes

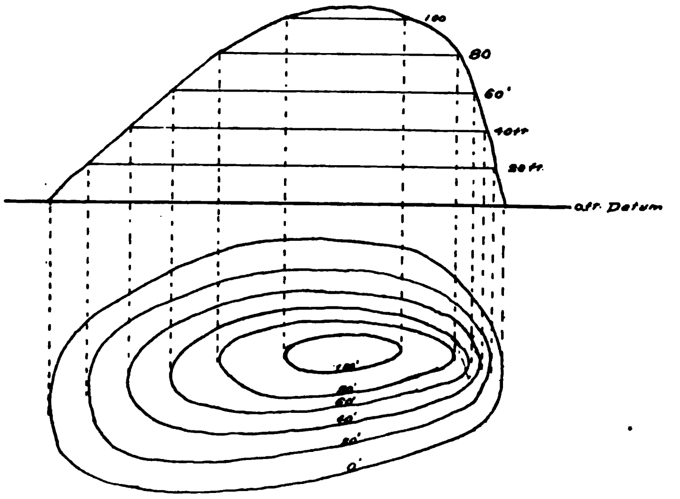
Before it is determined to use a diamond drill on the property either the state geologist should be consulted or the geological bulletins of the part of the country under investigation should be procured and studied. Most people do not realize how much work has already been done for them by their own state and country. If it is found that there are other measures beside the one under consideration which may have economical value or that the measure under consideration is covered by material, then at least one diamond drill hole should be drilled in order to locate and find the extent of these deposits. If this first drill hole should show possibilities then more of these should be drilled in order to determine if the material runs uniform and to determine the pitch and regularity of the measures.

If the body runs shallow then hand drills or wells should be dug at regular intervals, the location of which should be on the topographical map.

Clay Testing

From the drill holes and from the prospect holes all the material should be saved and an accurate log kept of each different kind of material, so that it can be tested and the tests made to correspond with the map. These tests and records will be discussed in detail later.

One of the first points to determine is the condition of the title to the property. When we obtain map No. 1 we notice there are two tunnel openings out of which coal has been taken. We have been assured that there was good coal on the property, but nothing was said about any quantity having been taken out. Further, it would look from the map that the clay prospect tunnel lay below the coal opening and if this is so, and very much coal had been removed, we should like to know whether or not this had destroyed the roof so that the getting out of the clay would be jeopardized.



Map 2. Method of Making Topographical Map

We see that there is a well on the property, also a creek and a river across the track.

1. What is the quality of this water?
2. Would it cause scale or scum in boilers?
3. Is either stream capable of generating power?
4. Is either capable of barge transportation?
5. What is the value of the timber?
6. Does the engineer think there is sufficient timber to furnish all the mine timber necessary for all the mine development?
7. Is there any other clay on the property?
8. Is the farm land sufficiently level and above the river to make safe factory site without great expense for drainage or filling?
9. Is the river in the habit of overflowing and causing damage?
10. Can the private road be closed and shut off the close route to the town?
11. What is the policy of the D. & R. G. R. R. about taking care of its customers in time of car shortage?
12. Is the property entirely dependent on one railroad?
13. How far would a private line have to be built to connect with a competitive road?
14. Could the right of way be obtained without being held up?
15. Could the surrounding property be optioned at a reasonable price if the company should desire expansion?

All of these questions should be answered and outside parties set to work to obtain options on the surrounding farms pending further investigations, since it is always cheaper to obtain a price on adjoining property before any improvement is made than afterwards. Many a company has had to pay dearly for this lack of foresight.

While all these questions are being looked up and the water being analyzed for boiler work we investigate the housing problem for the employes, the sanitary conditions, and also the labor market.

When the engineer reports on these points and everything looks still favorable to the proposition we appropriate more money and decide that we should know more about the resources of the property. Hence, we order the engineer to make a topographical map and start some diamond drills to working. We decide on ten holes, the depth depending on the results of the first hole which we decide to drill thru all the measures.

The work thus far has cost us $1,000 and we would not take ten times that amount for what we have already learned.

Topographical Map

In order that we may be in position to get all there is out of the topographical map that we have ordered made we will find out just how these are constructed and what is their value.

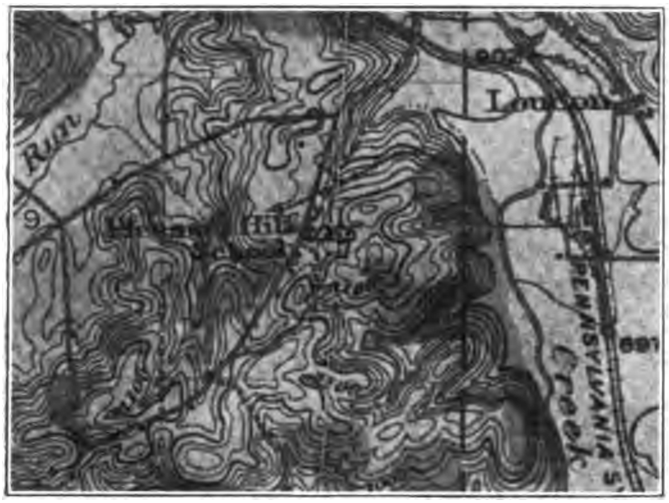


Fig. 3. Section of Government Topographical Map Covering Property Under Discussion

A topographical map is one which shows with practical accuracy all the drainage, culture, and relief features that the scale of the map will permit. These maps on a large scale are made by our Government and are published by the Coast and Geodetic Survey or by the United States Geological Survey. No clayworker should be without the one which shows his district. These can be procured for the sum of five or six cents by writing to Washington, D. C.

Map No. 2 shows how these maps are constructed. We will consider the hill A (shown in the upper part), and on its surface at every increase in altitude of 20 feet we will mark a station. In mapping we simply project these lines on the map we have already prepared and follow around the hills with a line of selected height. Part B (the lower part of illustration), shows this process and we can now consider that we are looking down on the hill from an airplane and that each line represents an elevation of 20 feet.

It will be noted that the more precipitous the hill the closer together will be the lines of elevation. These elevation lines on a topographical map are called contour lines. In the illustration the difference of elevation has been chosen at 20 feet, but where close work is necessary and the country is flat any interval may be chosen. Drainage maps are often prepared with one foot interval. This arbitrary interval is known as the contour interval and should be plainly marked on the map.

How We Can Apply These Maps to Our Needs

Very often we do not feel like going to the expense of having a topographical map made of the property we already have in our possession, and for this reason we shall diverge from the main topic and show how, at very little expense, we can apply the Government maps to our own needs. Nearly every firm has a large scale drawing of its properties. This can be made into a topographical map with very little expense.

Having procured the Government topographical map we will find that section which contains our property and mark it in ink. We will then take it to the nearest photographer who has an enlarging camera and for three dollars he will photograph on a larger scale this portion. Figure 3 shows such a portion cut from a United States Geological Survey map. We will now take the large scale map that we have made and with the aid of a cheap pantagraph trace the contour lines from the photographic enlargement to our map. The pantagraph will take care of the change of scales; all that is necessary is to find two or three common points on the two maps. Figure 4 will show the contour lines transferred to the large map. Having procured this map let us see how it can justify its expense.

Use of the Map.

1. Given the pitch of your measures you can calculate just how much overburden you will have to remove at any place on your property without further surveys and this can be done at any time.
2. It will easily show how deep from the surface you will have to go to strike any measure.
3. It will show just where any body of clay should be opened in order to get the proper drainage.
4. It will show the most economical grades for your railroads and other roads for hauling purposes.
5. It will show just how much material your neighbor has should you desire to purchase.
6. It will show where to look for out-cropping of any measure.
7. It will show just how all drainage systems should be laid out.
8. It will show just how far the water will seep thru from the streams.
9. It will show just how deep you can dig your dry pan pits without running into flooded water.
10. It will show how much grading and filling you will need for any new building.
11. It will show when water reaches the well hole in your kilns and how deep you dare dig these to be safe.

Since we now know how to read a topographical map we are ready to receive the first report from our engineer. While he was surveying for the topography he reported to us that he had found a large body of clay near the top of the hill and that it had very little cover on it. We immediately ordered him to send us samples of this material which we sent to the laboratory for testing. The material proved to be shale and our friend who told us of this property knew nothing of the worth of this material since the only clay he was familiar with that was of value was fire clay that occurred underneath the coal.

Topography Applied to Our Clay Prospect.

We will now turn to our topographical map No. 5, which is a duplicate of map No. 1, except that it has the added features of elevation and also the position of the diamond drill holes have been accurately located. Let us study this map in connection with the questions that came to our mind when we were looking over map No. 1.

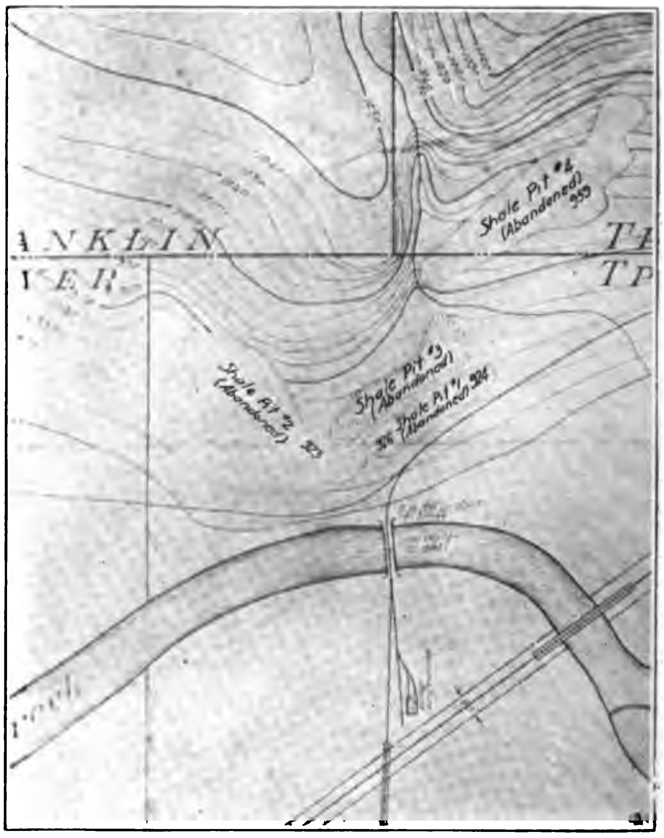

Shale Pit #4 (Abandoned) 355
Shale Pit #3 (Abandoned)
Shale Pit #2 (Abandoned) 323
Shale Pit #1 (Abandoned) 326

Fig. 4. Enlarged Map Showing Contour Lines

1. What is the quality of the water?

The analysis of the water from the well showed that it was safe for drinking purposes but was very strong in lime and would give considerable trouble due to scaling in the boilers.

The creek water was not safe for drinking, but had very little impurity so that a chlorine treatment would make it entirely sanitary, also the boiler compound people could furnish us a satisfactory compound that would take care of what little scaling effect it possessed. Further, our engineer reported that there was abundant water flowing at all times of the year to furnish water for fire purposes and also for factory purposes. He also reported that upon the property of Mr. Y, at the north, there was a natural reservoir where the creek could be dammed and the water conveyed thru a pipe along the contours of the creek until the 120 foot contour was reached and there it could be taken thru the old coal tunnel immediately above the factory site. This would give a natural head of 160 feet and would take care of all fire protection and render all pumping unnecessary.

We immediately turn to our map No. 5 and can very soon trace this and know that this is entirely so, as far as our property was concerned. But how about Mr. Y; would he sell? We had already anticipated Mr. Y, and we have a report from him. The river water was very poor for boilers as it was contaminated from the coal mines further up stream.

Question 2. Would it cause scum or scale in boilers? We have already answered this point.

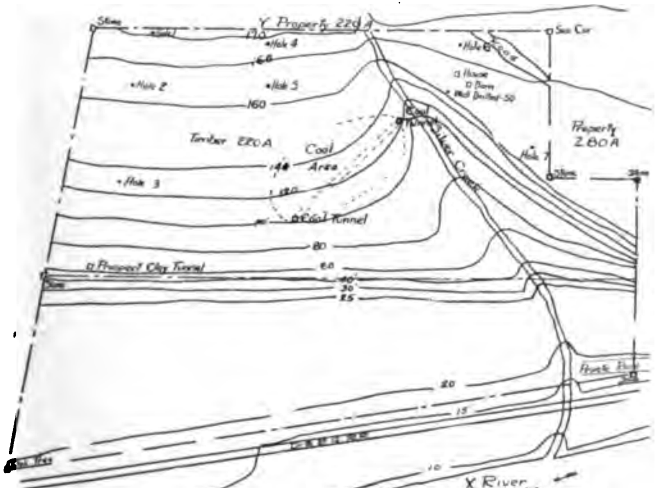
Question 3. Is either stream capable of generating power? The small stream has not sufficient continuous flow to make it valuable. The large stream has some possibilities, but our engineer doubts if the expense would be justified considering the cheapness of the local fuel.

Question 4. Is the river capable of large transportation? No, not without Government improvement.

Question 5. What is the value of the timber? Our engineer reports that there is sufficient quantity and quality to furnish all the mine timber necessary to develop the whole property provided that the cutting is done carefully and intelligently and referred us to certain Government bulletins from the Department of Forestry that tell just how this should be done. How to first eliminate some weed trees so the others will have opportunity of growth is one important consideration.

Question 6. Answered with question 5.

Question 7. Is there any other clay on the property? Yes. There is a large shale measure about 27 feet in thickness which reaches from contour 140 feet to 165 feet and in places it has no cover. He further reports that the bulk of this clay is on the land of Mr. Y, both north and west, and also that there is a large amount of virgin coal under this property, judging from the dip of the measures and the topography of the land. Any other clay will be shown from the drill records.



Map 5. Same as Map 1 with Contour Lines and Position of Drill Holes Shown

Question 8. Is the farm land sufficiently level and above the river to make a safe factory site without great expense in drainage or filling in?

We will again refer to our topographical map No. 5 and without the advice of our engineer we can answer this question for ourselves. We see from the map that the river has never overflowed the D. & R. G. tracks. This means that it has never gone over the fifteen foot contour. The main portion of the factory site lies between the twenty and the twenty-five foot contour. This means that we can excavate five feet without reaching the high water mark of the river. Also under normal conditions we would have a fifteen foot fall for all sewers and drainage. Further we notice from the contours that the factory site is comparatively level, only varying five feet over the entire area. It will be noticed that the railroad grade is a little below the fifteen foot contour so that we could have a slight grade into the factory and still have depressed tracks for loading, dropping down the loaded cars as they are loaded, by gravity.

Question 9. Is the river in the habit of overflowing and causing damage? When our engineer stated that the river had never been over the D. & R. G. tracks, and these were only 15 feet above the river in a country of hills, we had considerable doubt until we looked at the larger Government topographical map of this section and discovered that on the opposite side of the stream there was a large flat with a very low bank and we could readily see that in flood period this would allow the water to cover this entire area, thus taking care of the flood without materially raising the height of the stream.

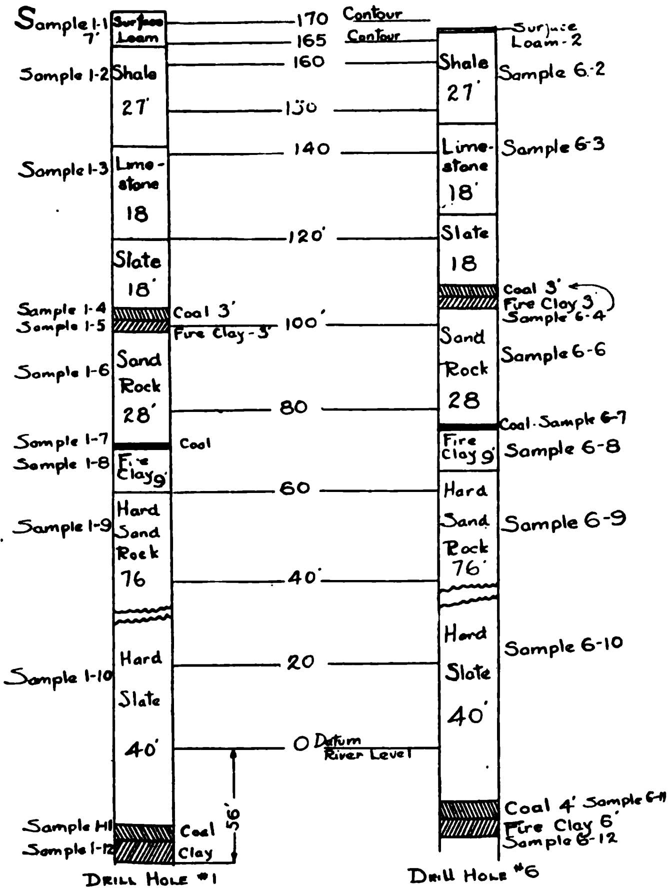


Fig. 6. Log of Holes 1 and 6 on Map 5

Question 10. Can the private road be closed, thus shutting off the near road to the town? No. It leads directly from the property under consideration to a public highway.

Question 11. What is the policy of the D. & R. G. about taking care of its customers in time of car shortage? We were informed from other shippers along the line that this trouble was often very real, not from lack of willingness on their part, but from lack of personally owned equipment, and when foreign lines were in need of their own equipment and withdrew it to their own lines, customers along this line suffered materially.

Questions 12 and 13. Is the property entirely dependent on one railroad? Our engineer reports that by constructing a half mile of track the property can be connected with a main trunk line.

Question 14. Could the right of way be obtained without excessive cost? Again we are informed that if we would construct a factory on the proposed site that the Chamber of Commerce of the town would donate this right of way.

Question 15. Could the adjoining property be obtained at a reasonable price should the company desire expansion?

After the engineer's report considering the discovery of the shale on the 140 foot contour and also the amount of coal worked out on the property being investigated, this phase of the situation loomed quite large in the success of the whole situation. A report was finally obtained from a third party working on the case that Mr. Y would sell his holdings or any portion thereof over 100 acres for $100 per acre. We instructed this party to try and get a six months' option at this figure with the privilege of prospecting. This was done for a figure of $500. Mr. Z was an obstinate individual and would not even consider an offer of once and a half the real value of his property so it was decided to let him keep his holding as the company did not wish to be stung if they could avoid it.

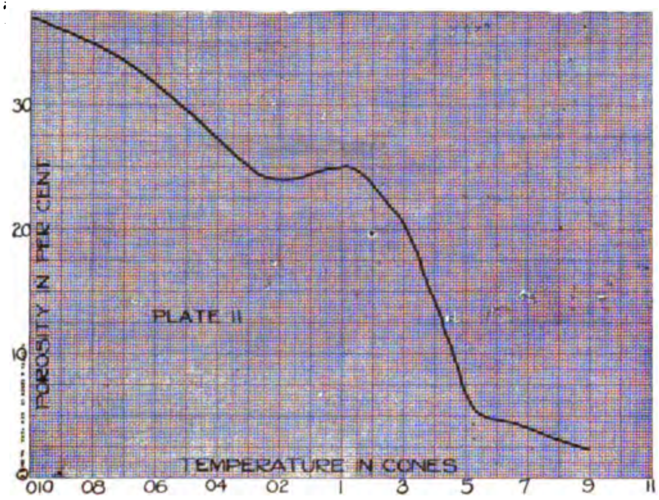


Fig. 11. Porosity of Sample 1-1 from Hole 1. This Clay Burned Safely Between Cones 5 and 9, but Overburned At Cone 10.

All questions of this nature were anticipated by studying the case before purchase rather than experience serious losses and readjustment afterward.

Diamond Drills

We now come to the work of the diamond drills and their connection with the map and the ultimate development. A diamond drill works in most respects like a butter sampler. It is a hollow tube which bores itself down into the earth, bringing to the surface an exact core of the material found below the surface. This core is from two inches in diameter to greater diameters, depending on the size of the drill. A core two inches to two and one-half inches is large enough to give a good sample for testing purposes. An accurate log of this core should be kept, showing at just what depths each change of material is met and when the core is removed the different sections can be removed, packed up with their description and sent to the laboratory for testing. In order to illustrate the use of the log we will reproduce the log from holes one and six of map No. 5 (see Fig. 6).

The following is the log of hole No. 1, elevation 174 feet, the distance being taken from the surface down:

0 feet to 7 feet. Surface loam of clayish nature. Sticky. Sample 1-1.

7 feet to 34 feet. Shale-like material with small bands of reddish sand-like material scattered thru it at variable distances from one to four feet. Sand seams are small, varying from one-fourth inch to three-fourths inch in thickness. Sample 1-2.

34 feet to 52 feet. Limestone. Sample 1-3. Have learned that local farmers are in the habit of collecting this material and burning it in mounds, then scattering the same on their field to increase their crops. Would advise having sample analyzed for possibilities for agricultural lime.

52 feet to 70 feet. Hard slate-like substance of no value.

70 feet to 73 feet. Well defined coal seam of fair quality. Same as is being mined several places in the valley. Sample 1-4.

73 feet to 76 feet. Fire clay. Very dark and plastic. Would say it was very high in organic matter and carbon. When exposed to the air it weathered into little cubes. Sample 1-5.

76 feet to 104 feet. Sand rock. Sample 1-6.

104 feet to 105 feet. Coal of poor bony nature. Sample 1-7.

105 feet to 114 feet. Fire clay. Hard and sandy. This is the same material as was taken from prospect tunnel but drill hole sample was much harder and more sandy. Material from the prospect tunnel must have been weathered over a long period or was affected in the side of the hill by surface waters. Sample 1-8.

114 feet to 190 feet. Hard sandrock material. Sample 1-9.

190 feet to 220 feet. Hard slate-like material, very black. Sample 1-10.

220 feet to 224 feet. Coal. Seemingly very good grade. Very free from sulphur and bone. Much better than the upper coal.

224 feet to 230 feet. Fire clay. This sample seems to be very uniform and looks like a high grade fire clay. Would advise it being tested very carefully. Sample 1-12.

Hole stopped at this point, as state geological reports showed that measures below were very thick and uninteresting, and after the lower coal was located and found to be present on this property it was decided to sink all the remaining drill holes to this level and see if it ran without break on the property, since in some districts there had been a great deal of faulting in this measure.

The following is the log of hole No. 6, elevation 168 feet, the distances being taken from the surface down:

0 feet to 2 feet. Surface loam of a clayish nature. Sample 6-1.

2 feet to 29 feet. Shale-like material with small bands of sand-like material scattered thru it. Resembles Sample 1-2 very closely and in comparing the two samples and the distance between the two holes would say that the material was very uniform. Very light in carbon. Material pretty well weathered and much softer than Sample 1-2. Sample 6-2.

29 feet to 47 feet. Limestone. Closely resembling Sample 1-3. Sample 6-3.

47 feet to 65 feet. Hard slate-like substance of no value.

65 feet to 68 feet. Well defined coal seam. Same as Sample 1-4, with exception that the quality seems somewhat better. Sample 6-4.

68 feet to 71 feet. Fire clay. Same appearance as Sample 1-5. Sample 6-5.

71 feet to 99 feet. Sand rock. Sample 6-6.

99 feet to 100 feet. Coal, poor bony nature. Sample 6-7.

100 feet to 109 feet. Fire clay. Hard and sandy. Same can be said of this measure at this point as was said in the first hole. Sample 6-8.

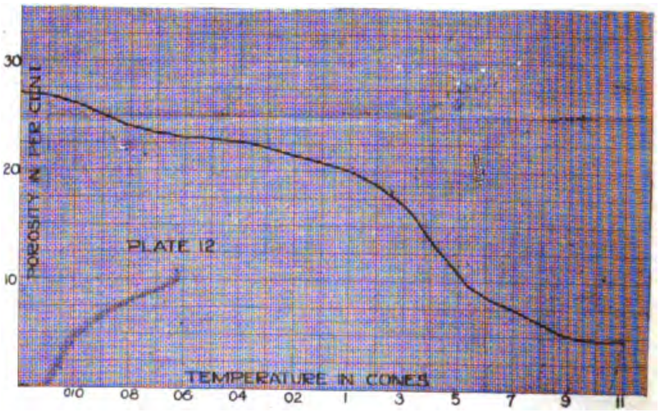


Fig. 12. Porosity of Sample 1-8 from Hole 1. This ranks as a No. 3 Fire Clay

109 feet to 185 feet. Hard sand rock material. Sample 6-9.

185 feet to 215 feet. Hard slate-like material. Very black. Sample 6-10.

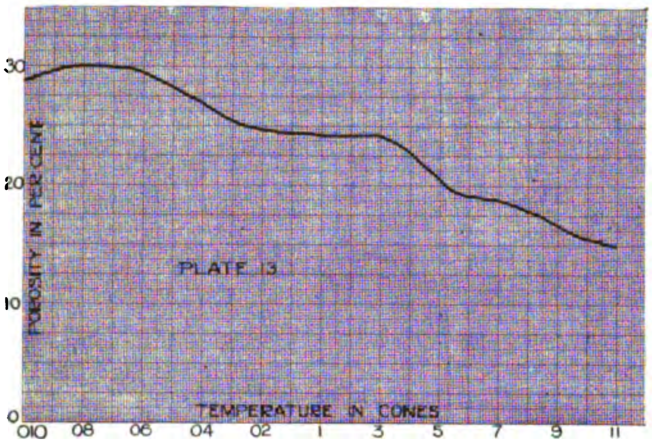
215 feet to 219 feet. Coal. Very good coal. A small seam of sulphur rock was noticed thru the measure. This seam was about one-half inch in thickness. Sample 6-11.

219 feet to 225 feet. Fire clay. Very good grade, same as Sample 1-12. Sample 6-12.

We will now examine the drawing made from the log of holes one and six.

First: We see that the measures run very uniform between these two holes and this was found true between the other holes. This means that in mining we will not face dangerous faults and lose the measure after spending a lot of money in development work.

Second: We see between holes one and six that the measures rise a matter of five feet and from the other drill holes we find that the general pitch is toward the northeast. This tells us that the mine should be opened on the front side of the hill and the layout should be made toward the northeast. In this way all pumping will be avoided and the mine will be self draining. Further all loads will come from the mine on a down grade which will be a material saving in haulage charges. Probably these two items alone would have justified all the money expended thus far.



Porosity of Sample 1-12 from Hole 1. This Ranks as a No. 1 Fire Clay as the Fusion Point is Above Cone 30

Third: By drilling we found that the shale measure ran uniformly around the hill and that the material itself was very uniform in quality.

Fourth: We found that the fire clay which we originally went out to prospect is not of the same quality in the hill as it appeared to be in the prospect tunnel which was driven in the hill a matter of 100 feet. This was undoubtedly due to the effect of the surface waters on the clay near the out-crop which weathered the material, making it a great deal more plastic and workable.

Fifth: We discovered a limestone which we did not expect existed on the property and which might be turned into a commercial possibility.

Sixth: We discovered a better coal measure 45 feet below the river than the one we originally sought. Further it had a roof of very hard material which would keep the water out and had every assurance of giving us a dry mine.

Seventh: We found below this coal a fire clay which seemed to have refractory possibilities. Of course we cannot be entirely sure of this until we have the results from the laboratory, but the results of the observation tests look very encouraging.

Eighth: The drill records showed that all materials that were to be mined were overladen with a material which should give a very good roof and render mining comparatively safe without excessive cost for timbering.

Ninth: The drill records gave us an accurate gauge whereby estimates could be made for sinking a shaft for the lower clay and coal. The engineers from this record knew just what kind of material they would have to go thru.

Laboratory Tests of Drill Hole Samples

For a new project it is not sufficient that a friend burn a piece of clay in his kilns and report on the same, or that a machinery company make a report on the same. Both of these things are well to do. It is a good thing to have a machinery company test the clays, as they have had a fund of experience, and their advices are always good for checking purposes.

The great danger of having a friend in the clay business make the tests is that his kilns are not, as a rule, adapted to burning different clays, and his burning temperature is usually either too high or too low, and for this reason it is nearly impossible for him to do a clay justice. The best method is to have a report made and tests by a competent ceramic engineer. This report should tell the following facts:

First: Working qualities. Whether the clay will laminate; whether this can be overcome; whether it is too plastic or too short, and whether the qualities are bad enough to make manufacture unsafe.

Second: The report should tell all the uses to which this clay can be put.

Third: The burning test should be conducted at different temperatures and a curve plotted for each clay which will indicate the range of temperature of safe burning and also the ultimate fusing point.

Fourth: The report should indicate whether or not the clay can be glazed with salt.

Fifth: A test should be conducted to find out any tendency toward scumming and the amount of barium necessary to add to overcome this tendency.

The report will contain many other items, but these points are very essential.

We will now consider that this work has been done and apply the information to the clay problem at hand. The laboratory reported that Sample 1 was a shale of good working qualities of sufficient plasticity for brick and could be worked on either an auger machine or a sewer pipe press. It was free from lamination and scumming qualities. The report said that it did not seem to glaze very well, but with an admixture of Sample 8 taken from the prospect tunnel it glazed very satisfactorily.

The curve Fig. No. 7 showed that it was very safe burning and was a good body between cones 5 and 9 and was overburned at cone 10. The rattler test showed a loss of 18 per cent. It was recommended very strongly for paving brick and would make a red burning sewer pipe with a twenty-five per cent. mixture with H-8 taken from the outcrop.

Sample 8. This was the material we first started out to investigate. The laboratory reported that all the samples from the drill holes were too short or had too little plasticity to hold up on a sewer pipe press and that fine grinding and long panning did not give it sufficient plasticity for this purpose, but that the sample taken from the prospect tunnel had good plasticity and working qualities and from the contour map it appeared that there should be ample material of the weathered material to mix with the shale and make sewer pipe for eighty years and if property west of the present site could be purchased a good sewer pipe plant could be assured. Fig. No. 8 shows the porosity curve for this clay, and it can be ranked as a No. 3 fire clay. It develops a good strong body between cones 7 and 11 and is overburned at cone 14. The laboratory reports that the weathered material would be a good addition to a chemical stoneware body.

Sample H12. The laboratory was very enthusiastic about the lower fire clay, stating that it had splendid working qualities and an extremely strong bond. Its refractoriness and fusing point of cone 30 placed it in the No. 1 fire clay group and a very high grade refractory could be produced from it. Fig. No. 9 shows the porosity curve of this material.

Conclusion

After all the reports were in it was decided to finance a company three times as large as the first one conceived, but that instead of sewer pipe, as was originally planned, that a refractory plant and a paving brick plant be built first and the sewer pipe plant to follow.

A shaft was to be started immediately for the best fire clay and a steam shovel purchased and first started cutting a depressed track on the factory site, then it was to be moved up the hill on the shale, following around the hill and not stripping till it was found necessary. When the sewer pipe plant was started it was decided to buy a second steam shovel and have it work on the outcrop of the No. 8 fire clay and use this shovel during its months of idleness to strip any of the shale that needed it.

A railroad was to be connected to the trunk line and all of Mr. Y's property purchased.

The Value of a Clay Deposit

These formulae for the value of the clay deposits are based on the fact that if every year there should be deposited in a sinking fund an amount equal to the value of C in each instance, multiplied by the tonnage taken out, the sinking fund at the end of the term represented by Y would be large enough to repay the total value represented by the formula and interest on the value of clay deposit remaining unused each year. A little figuring in each case will prove the formulae.

The formulae for the value of the surface land are based on the same principle, except that the amount to be deposited in the sinking fund would be equal to the value of I, multiplied by the value of the surface land undisturbed by the clay digging operations. The value per acre of the land undisturbed is to be found by dividing the original value, as found by the formula, by the original number of acres.

All of the surface land values given herein are based on the assumption that when the clay is dug, the surface land is rendered unfit for any further use. In the very few cases where the surface would not be disturbed, or where the land would be of any later use, these values will not govern. These cases can be governed by adding to the present value of the surface land, as determined by ordinary methods, the value of the clay deposit as shown in this article.

All of the values shown herein are arrived at irrespective of the value or equipment of the plant using the clay, except the value of Y which must be determined by the amount to be used.

There are four basic conditions affecting the value of land containing a deposit of clay.

When the deposit of clay is being used, use the following formula:

$$(1)\quad V=\frac{2\ ATC}{2+I+IY}$$

When the deposit of clay is not being used, and its use will not commence this year, use the following formula:

$$(2)\quad W=\frac{2\ ATC}{(1+IZ)\ (2+I+IY)}$$

When the deposit of clay is being used and the surface has a value, use the following formula for the surface land value:

$$(3)\quad X=\frac{(API)\ (Y+1)}{2+I+IY}$$

When the deposit of clay is not being used and its use will not commence this year, and the surface land has a value, use the following formula for the surface land value:

$$(4)\quad R=\frac{API(Y+1)}{(2+I+IY)\ (1+IZ)}+\frac{APIZ}{(1+IZ)}$$

Evidently, when it is desired to find the total value of the land which has a surface value and contains the deposit, we must add together V and X or W and R, as the case may be.

In all of the formulae shown here the various characters represent the following values or figures:

V represents present value of deposit, if now being used, or if its use will be started in the present year.

A represents number of acres which are underlaid with clay.

T represents average tonnage per acre, estimated from average depth of deposit.

C represents the advantageous price per ton. This is the price per ton that the clay deposit is worth. This must be figured as a decimal of a dollar.

I represents the interest due on invested capital. When this is six per cent. it must be entered as .06.

Y represents the number of years that it is thought the deposit will last if used at a uniform rate, which in most cases must be estimated.

Z represents the number of years that it is thought the deposit will lay idle, or the number of years that will lapse before the continuous operation of clay digging will be started. When the term represented by Z is concluded, the term represented by Y begins.

W represents present value of clay deposit, if it is not now being used or if its use will not be started in the present year.

X equals the value of the surface land, when used for farming or other purpose on a piece of land which contains a deposit of clay which is being dug or will be this year. X represents the surface land value when V represents the clay deposit value.

R equals the value of surface land when used for farming or other purpose on a piece of land which contains a deposit of clay which is not being dug and which is not to be dug this year. R represents the surface land value when W represents the value of the clay deposit.

P represents the value per acre of the surface land for farming or other use.

We must be very careful in figuring the value of C. Of course, high grade clays, and clays that are hard to duplicate under similar conditions are worth a good price, but ordinarily this value must be figured low. Under no conditions should any digging equipment be taken into consideration when figuring this item. The installation of a steam shovel reduces the cost of operation of a clay pit, but under very few conditions does it increase the value of a deposit of clay. Of course, if the machinery equipment of a deposit of clay is owned by the same firm or individual as the deposit itself, and the entire plant and land is leased, the equipment has a small effect on the value of the deposit.

If a competitor is digging clay by antiquated methods, it would seem that C ought to be figured at the difference in the cost of operation of the two pits. This is not true. The value of C is really the advantage in cost of operation, which one pit enjoys over another if their equipment is equal or the advantage which it would enjoy if their equipment were equal.

Possibly Jones has a pit with modern equipment and can dig clay for ten cents per ton cheaper than Smith, who has an old style outfit. If Smith would put in modern equipment he would be able to dig clay for the same amount as Jones. Evidently, the value of C for the deposit operated by Jones would not be ten cents. His difference in cost of operation is a credit to his equipment and has no effect on the value of the deposit of clay.

The distance that clay must be hauled has a comparative effect on the value of a deposit. Of two deposits which are identical, the one at the plant and the other a half mile away, naturally the one at the plant is worth more. In figuring the value of C the difference in cost of transportation by equal equipment from the two pits must be taken into consideration. If Jones' pit is closer to his plant than is Smith's to his, so that with the most improved equipment for transportation at both pits, Jones could always transport his clay for five cents a ton less than Smith, it is evident that Jones can add five cents to any other monetary advantages he may have, to determine his value of C.

Drainage conditions also have a comparative effect on the value of two deposits of clay, because they directly affect the cost of operation. Depth of stripping must be considered for the same reason.

A clayworker can easily find the value of C for his condition by answering the following question: How much more per ton am I willing to pay for this piece of land containing a deposit of clay than for another?

Often owners think their land valuable because it is underlaid with clay. Cost of operation makes it useless. This method will determine that it has no value. We would suggest a minimum value of one cent for C, if a pit is actually in operation. Even tho the cost of operation is greater than that of another competitive pit, the assurance and satisfaction of depending on a proper supply of clay for the use of the plant ought to be worth that much.

If one firm has a lease on a royalty of 2½ cents a ton and since that lease was signed the price on surrounding land has increased to five cents per ton, the value of C for the owner of the lease is 2½ cents, providing other conditions are equal.

All natural conditions, but very few artificial conditions, have a bearing on the value of C.

The owner of a piece of land containing a deposit of clay which he has leased will figure his royalty prices as the value of C for his holdings.

133—CLAY TESTING

As the result of an effort to standardize clay testing for laboratory purposes, the following methods have been worked out. Each of the tests described has been in use for a considerable period of time and will be found to give satisfactory results for the purpose intended.

The forms shown in Figs. 1 and 2 are used to record results. These are printed side by side on a sheet 11 by 17 inches, folding to letter size when completed.

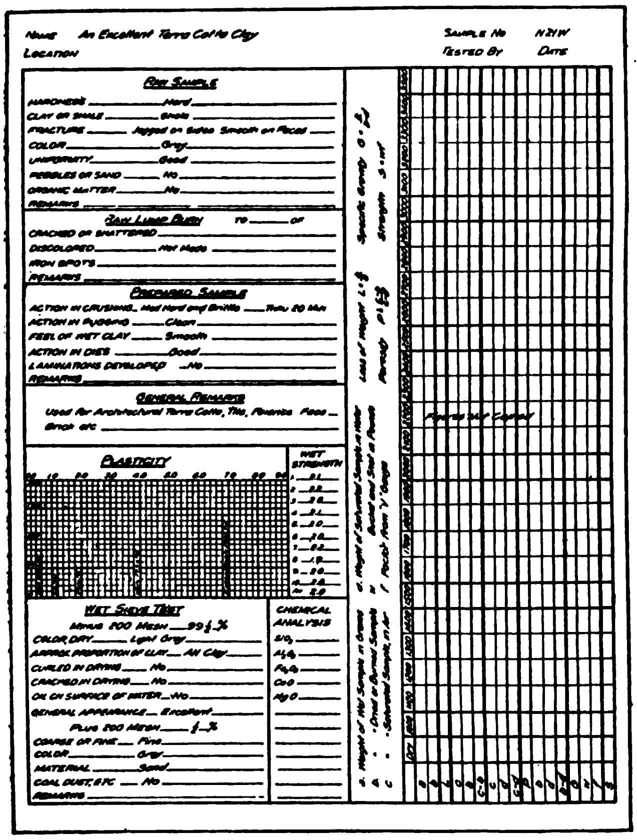
The general physical characteristics of the raw clay are first noted and recorded as indicated on the test sheets. These include color, hardness, fracture, uniformity, organic matter, foreign material, behavior in crushing, pugging, and forcing thru dies, and remarks of a general nature.

Plasticity is determined by noting the amount of water required to form a slip of standard thickness or viscosity. The clay is blunged, deflocculated to its maximum viscosity with suitable electrolyte, and diluted with water to a standard thickness. The amount of water contained in the slip is determined, which is the measure of plasticity.

How Various Tests are Conducted

If a deflocculating agent, such as hydrochloric acid, is not used, other adverse agents, which are frequently present, prevent the slip attaining maximum values, and erratic results will be shown. Attempts to determine the plasticity of clay on soft mud samples do not give satisfactory results, owing to the large and indeterminate influence of the non-plastic material present.

The standard viscosity for the clay slip is taken as one-tenth of the absolute unit, or one-tenth poise, equal to about ten times the viscosity of water at 20 deg. C. Hydrochloric acid is used for deflocculation. Typical plasticity curves are shown in Fig. 3.



Name An Excellent Terra Cotta Clay
Location

Raw Sample
Hardness — Hard
Clay or Shale — Shale
Fracture — Jagged on Edges Smooth on Faces
Color — Gray
Uniformity — Good
Pebbles or Sand — No
Organic Matter — No
Remarks

Raw Lump Burn to — °F
Cracked or Shattered
Discolored — Not Made
Iron Spots
Remarks

Prepared Sample
Action in Crushing — Not Hard and Brittle — Thru 20 Mesh
Action in Pugging — Clean
Feel of Wet Clay — Smooth
Action in Dies — Good
Laminations Developed — No
Remarks

General Remarks
Used for Architectural Terra Cotta, Tile, Fire? Face Brick etc

Wet Sieve Test
Minus 200 Mesh — 99½ %
Color, Dry — Light Gray
Approx. Proportion of Clay — All Clay
Curled in Drying — No
Cracked in Drying — No
Oil on Surface of Water — No
General Appearance — Excellent
Plus 200 Mesh — ½ %
Coarse or Fine — Fine
Color — Gray
Material — Sand
Coal Dust, Etc — No
Remarks

Chemical Analysis
SiO_2
Al_2O_3
Fe_2O_3
CaO
MgO

Sample No
Tested By
Date
Plasticity
0
10
20
30
40
50
60
70
80
90
Wet Strength
Specific Gravity
Strength
Loss of Weight
Porosity
a. Weight of Saturated Sample in Water
b. Dried and Sized in Pounds
Factor from 'V' Gauge
a. Weight of Wet Sample in Grams
b. Dried or Burned Sample
c. Saturated Sample in Air

Fig. 1. Form Used to Record the General Physical Characteristics of Raw Clay

The wet strength of the clay is determined in the breaking machine illustrated in Fig. 4. A sample having a net area of one square inch, similar to the samples used in cement testing, is employed. Sand poured thru a short nozzle three-eighths inch in diameter is used for breaking, the average of several samples being taken. The screw press and die are shown in Fig. 5.

For the separation of coarse material and impurities one hundred grams of clay are blunged into a thin slip and sieved thru a two hundred mesh screen. The plus two hundred mesh material is caught on the screen, removed and dried, and the weight and character noted.

The minus two hundred mesh material passes thru the screen into a half-gallon crock below, and is dried at about 160 deg. F., and the weight and character noted.

Chemical analysis is made in the customary manner and recorded in the space provided.

To test the drying qualities of the sample, one hundred grams of wet clay are pressed into a briquette and dried at 160 deg. F., under standard conditions. A balance and shrinkage gage, as shown in Fig. 6, indicates the loss of weight and the shrinkage simultaneously. These values are noted from time to time on the test sheet, and the drying curve is plotted as shown. If cracking develops during this test, it is noted on the forms. A hundred gram sample is found satisfactory, and in connection with the other information noted, gives an excellent idea of the drying properties of the clay.

Making Tests on Dried and Burned Samples

For tests on dry and burned material, bars one-half inch in diameter are expressed on to a grooved board and cut into five-inch lengths, as shown in Fig. 7. The bars are stamped with a sample number and notched with a hundred millimeter gage, as shown in Fig. 8, and the average wet weight is noted.

The samples on the rack are placed in a dryer at 160 deg. F. and dried under standard conditions. Should warping of the ware be likely to occur under ordinary commercial conditions, it will very probably be shown in the test.

Several of the dry sample bars are broken in the testing machine illustrated in Fig. 9. The broken sample, near the point of fracture, is dropped into the "V" gage, shown in Fig. 10, and the factor opposite the center of the bar noted. This factor multiplied by the breaking weight gives the strength of the bar, in transverse rupture in pounds per square inch. This strength corresponds very closely to the actual tensile strength of the clay, and successive tests will be found to check closely.

The burned-strength is later determined in a similar manner, as shown in Fig. 11.

The dry-shrinkage of the clay is measured with a millimeter scale, each millimeter representing one per cent. shrinkage. The dry shrinkage of the bars is slightly greater than that of the sample shown in Fig. 6, but as it seems to correspond more closely with the results obtained in actual commercial work, it is this value which is referred to as dry shrinkage.

About twenty-four samples are placed crosswise in an electric kiln, on supporting bars about 3½ inches on centers. With an oxidizing atmosphere, the temperature is raised at the rate of 100 deg. F. every ten minutes.

Unless special information is desired, the first sample is drawn at 1,000 deg. F. and at each 100 deg. F. thereafter. The samples are drawn with a long steel rod and dropped into a pan of asbestos. They will not air-check if the kiln is not allowed to cool before drawing.

While the electric furnace has been found satisfactory for general preliminary work, it is not recommended where great accuracy is desired. In such cases samples should be burned under commercial conditions and the results noted.

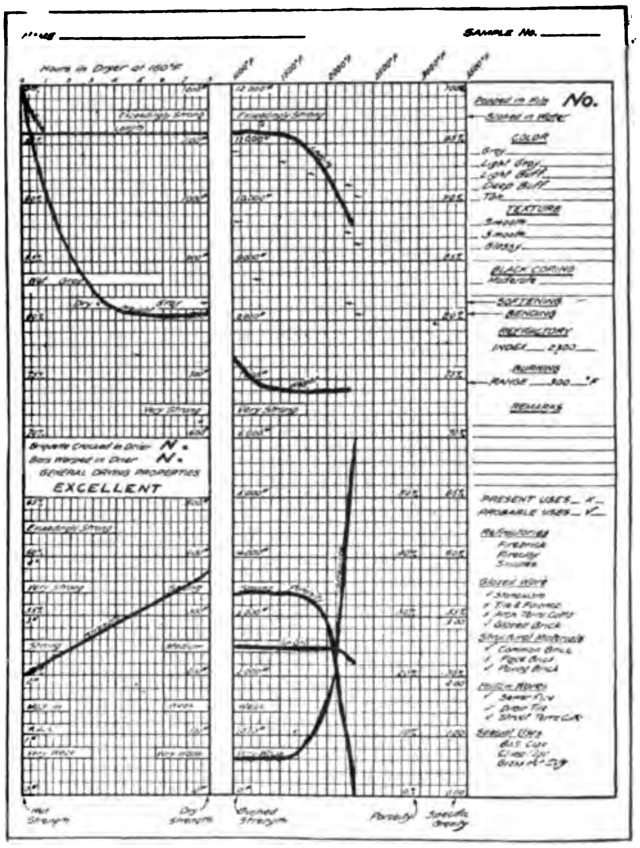


Fig. 2. Form on Which Drying and Burning Tests Are Recorded

When cool, the color, shrinkage, loss of weight, porosity, and specific gravity are determined in the usual manner. The samples are broken, and the strength and texture noted. This information is recorded by curves and figures on the form.

Determining Burning Characteristics

The point at which the sample sags noticeably in the kiln, under its own weight, is designated as the refractory index. A slight softening and stickiness will be noted at from 50 to 100 deg. F. below this point.

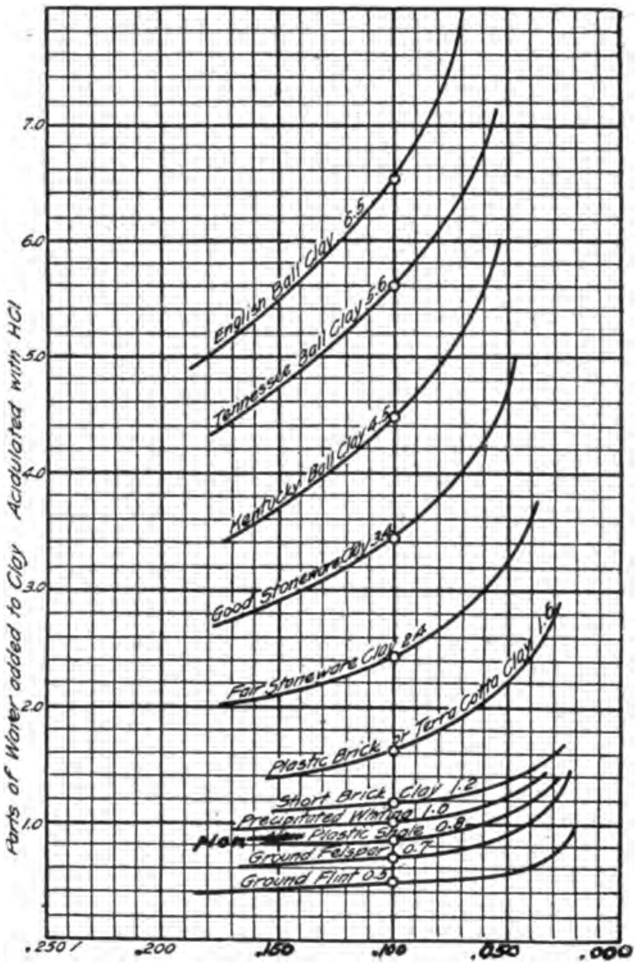


Fig. 3. Typical Plasticity Curves.

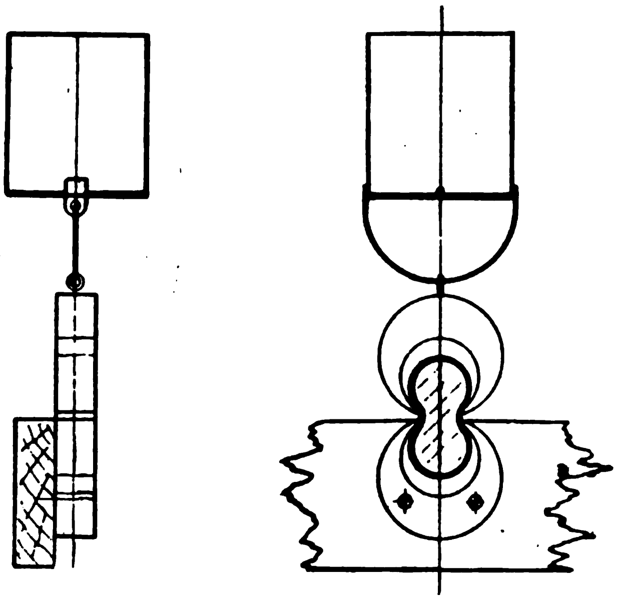


Fig 4. A Machine for Testing the Breaking Strength of Wet Clay

The burning range is taken from about the temperature at which the strength reaches a value of 1,500 pounds per square inch, up to the point of bending in the kiln.

This represents the burning range for extreme classes of ware. It is not intended to imply that paving brick, for example, should be burned to a strength of 1,500 pounds, or that refractories should be burned to several thousand pounds per square inch.

Vitrification is represented by a great increase in strength with a decrease in porosity, and the development of a dense, close, more or less glass-like body. The development of these characteristics is clearly indicated on the test sheet, but no attempt is made to fix any particular point as the point of vitrification.

In exceptional cases values as high as the following have been noted in different clays: Plasticity 6.6; wet strength 5.5; dry strength 1,710; burned strength 13,300.

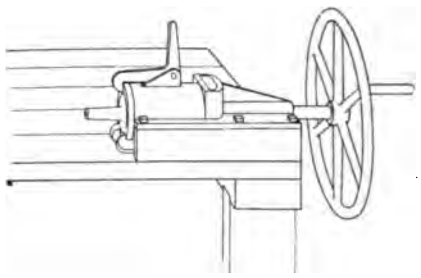


Fig. 5. Screw Press and Die for Making Sample Test Pieces

The strength test as an indication of the degree of vitrification, is far more sensitive than any other test known, according to some. A marked change occurs in this property many hundreds of degrees before any other change is noted, with the exception of that of color.

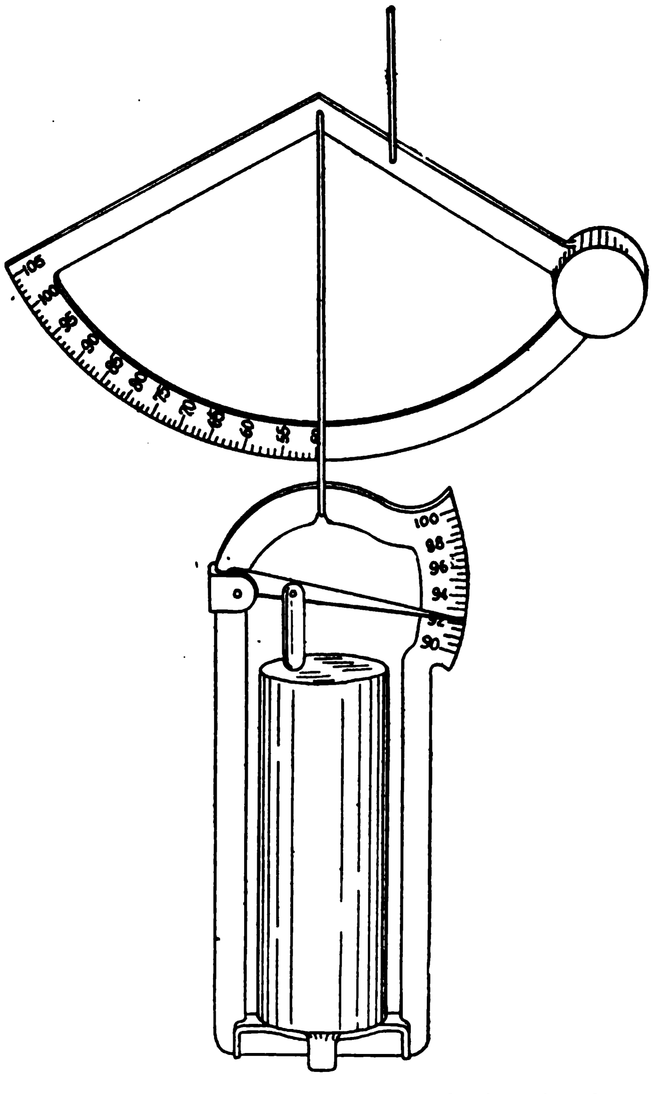


Fig. 6. An Apparatus Which Indicates the Loss in Weight and Shrinkage Simultaneously

By means of the above tests it is possible to determine the uses to which a clay may be put, or the characteristics required in the raw material if certain classes of ware are to be manufactured.

For convenience in the systematic testing, the following directions have been prepared:

Directions for Clay Testing

1. A raw sample of about ten pounds weight is required.

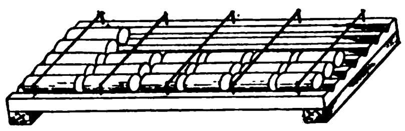


Fig. 7. Method of Cutting Bars for Test

2. Note characteristics as indicated on form under raw sample.

3. Dry and place in two gallon jar.

4. Crush six pounds, dry weight.

5. Grind thru 20 mesh screen for plastic clays and 40 mesh screen for shales. For non-plastic clays grind to 100 mesh and use gum tragacanth or other similar binding agent.

6. Note how clay acted in crushing and drying.

7. Place in wet pan and mix thoroly while dry to insure uniformity.

8. Remove 800 grams for wet-sieve and plasticity tests.

9. Pug sample remaining in wet pan to proper consistency.

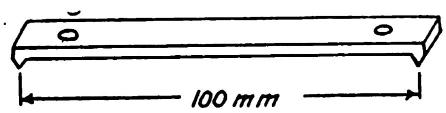


Fig. 8. Hundred Millimeter Gage

10. Note how the clay acted in pugging.

11. Hard clays and shales should be aged 24 hours. Soft clays usually require no aging.

12. To measure plasticity:

a. Place 400 grams of water in an electric blunger—the familiar soda fountain egg-beater is excellent. Add ground clay as per table to form an aliquot part. A short clay will require about a one part mixture. A good ball clay will take a four to six part mixture. Blunge until thoroly dissolved—from 5 to 60 minutes.

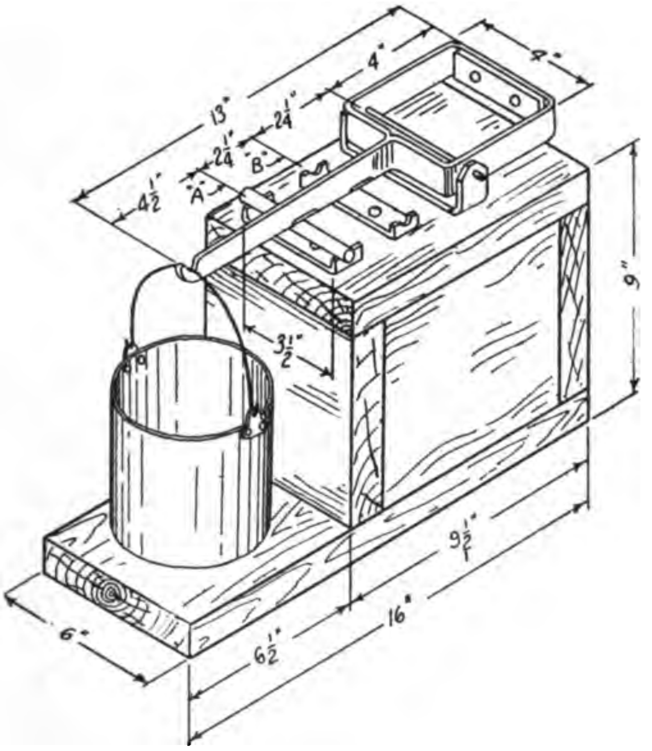


Fig. 9. Machine to Determine Breaking Strength of Clay

b. Determine viscosity in poises, and mark point on extreme right hand line of squared paper. Add one drop of commerical hydrochloric acid to slip in cup, stirring with plunger while running. Note viscosity, and record on line to left of last point noted. Repeat operation until a maximum value is reached and the curve is flat. Transfer this point to proper column under number of parts of water used.

c. Dilute with water as per table and note viscosity for one or more additional points. Plot curve. The number of parts of water producing a viscosity of 1/10 poise is the index of the plasticity of the clay.

Example: To make about 400 cc. of a three part mixture: to 400 of water add 133.3 gr. of dry material. To dilute this three part mixture to a four part mixture: to 400 gr. of mixture, add 100 gr. water. To dilute a four part mixture to a 5 part mixture: To 400 gr. of mixture, add 80 gr. of water.

13. Record numerical value of plasticity in proper place on form.

14. For wet sieve test place 100 grams of dry ground clay in about 300 cc. of water in blunger. Stir until thoroly dissolved. (Put water in first.)

15. When thoroly dissolved, pour contents of bottle on to the 200 mesh screen in the wet sieve machine, using plenty of water to wash out the bottle. Plus 200 mesh material is caught on the screen. Minus 200 material passes thru into the one-half gallon milk crock below.

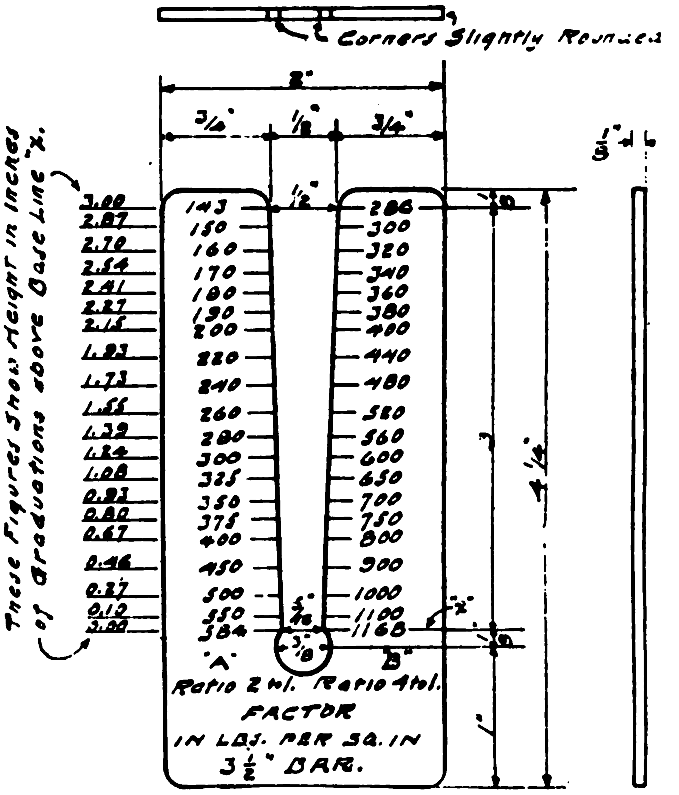


Fig. 10. Gage to Determine Factor by Which to Find Strength of Bar

16. Wash the material remaining on the screen into a bowl under a small stream of water from the faucet. This plus 200 material should consist of fine sand, mica, etc., without clay particles, which can be crushed between the fingers. Water running off should be clear. Place in the dryer.

17. Place the minus 200 material in the dryer.

18. If the clay has been aged, re-pug to proper consistency.

19. Work by hand into solid mass and place in a cylinder press.

20. Attach figure 8 die, and run out a 12 or 14 inch length of clay. Die should be clean and bright inside and wet before using. Cut into one inch lengths with gang cutter.

21. Make wet strength test on ten samples, taking the weight of the bucket, sand, clamp and lower half of the sample in pounds. Recover clean samples which remain in the upper clamp, wasting the sanded samples which falls into the bucket. Record weights on form.

22. Attach ⅛ inch die and fill one V-rack with samples.

23. With wire cutter, notch one-half inch samples about one-fourth way thru with a sliding stroke, in front of each pair of guide posts, making 32 samples one-half inch by five inches. The samples should lie straight and true in the bottom of the grooves.

For Diluting Contents of Mixture

Weight of Mixture	Parts of Water to One Part of Dry Material 1	2	3	4	5	6	7	8	9	10
100	50	33.3	25	20	16.7	14.3	12.5	11.1	10	9.1
200	100	66.7	50	40	33.3	28.6	25	22.2	20	18.2
300	150	100	75	60	50	42.8	37.5	33.3	30	27.3
400	200	133.3	100	80	66.7	57.1	50	44.4	40	36.4
500	250	166.7	125	100	83.3	71.4	62.5	55.5	50	45.5
600	300	200	150	120	100	85.7	75	66.6	60	54.6

For Mixing Dry Materials To Be Added to Water

Weight of Water	Parts of Water to One Part of Dry Material 1	2	3	4	5	6	7	8	9	10
100	100	50	33.3	25	20	16.7	14.3	12.5	11.1	10
200	200	100	66.7	50	40	33.3	28.6	25	22.2	20
300	300	150	100	75	60	50	42.8	37.5	33.3	30
400	400	200	133.3	100	80	66.7	57.1	50	44.4	40
500	500	250	166.7	125	100	83.3	71.4	62.5	55.5	50
600	600	300	200	150	120	100	85.7	75	66.6	60

24. Remove one string of four samples and weigh, recording average weight of one sample as wet weight "A" on the form. Surplus clay should be removed from ends of string before weighing.

25. Note color of wet clay.

26. Note how clay acted in the die.

27. Mark sample number with stencil about 1½ in. from left end of samples.

28. Loosen samples slightly with fingers to prevent sticking.

29. Notch samples lightly with 100 mm. gage.

30. Place rack and samples in dryer.

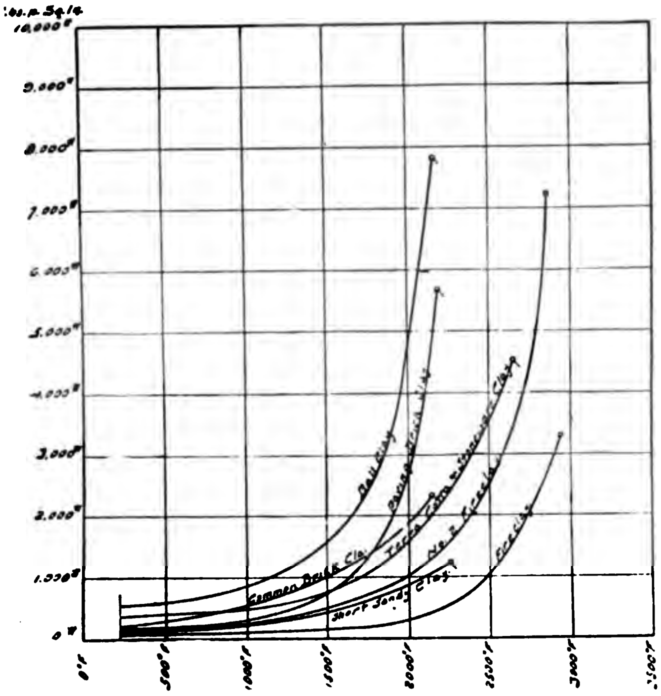


Fig. 11. Typical Burned Strength Curves for the Various Classes of Clay Products

31. Press 100 grams of wet clay in a briquette mold. Stamp and sample number on briquette.

32. Place briquette in test dryer. Thermometer should stand at 150 deg. F. and clock at 12M. Record loss of weight and shrinkage every ten minutes, plotting curve on form.

33. When 5 in. samples are thoroly dry, remove from dryer on rack.

34. Note if the samples have been warped in the dryer.

35. Break the samples carefully at 5 in. notches. Only the straightest and most perfect should be put in the kiln, others being reserved for dry-strength test.

36. Place 27 samples in an electric kiln on supporting racks. Samples should not touch sides or bottoms of kiln. Place numbered end to left side of kiln.

37. Burn kiln slowly at first, until samples are thoroly heated thru; afterwards at the rate of 100 deg. rise each ten minutes.

38. Extremely fine grain clays may pop in kiln. In this case, they must be heated very slowly until red heat is reached.

39. When 1,000 deg. F. is reached, remove one sample and drop into a panful of asbestos. At each succeeding 100 deg. draw an additional sample. Mark samples on right end when cool with lead pencil, and place on rack with the dry samples.

40. When the bars in the kiln soften and stick slightly, the burn is nearly completed. When bars bend under their own weight the burn is complete, and the power is shut off.

41. Record length in mm. of each sample, including dry bars plotting curve direct.

42. Record color of dry and burned samples.

43. Record dry or burned weight of samples under "b" on form.

44. Soak burned samples in water five or six hours, nearly submerged.

45. Weigh samples submerged in water and record as "d."

46. Roll sample on dry towel to remove surplus water.

47. Weigh in air and record as "c."

48. Break dry and burned samples in the bar machine, and weigh the bucket and shot. Record as "w." The average of several dry bars should be taken.

49. Place broken bar in "V" gage and read factor opposite the center of bar. Record as "f."

50. Note amount and point at which black coring disappears, if present at all.

51. Note texture of break in burned samples.

52. Note if lamination or piping has been produced in die as shown by broken sample.

53. When water is entirely evaporated, remove bowl from dryer. Note cracking, curling, etc., as indicated on form.

54. Note character and weight of plus 200 and record as indicated on form.

55. Make necessary calculations from above data and plot curves for length, weight, porosity, specific gravity, strength, etc. Record miscellaneous data as indicated on form.

56. If chemical analysis is determined, record on form.

57. Note burning range from temperature at which 1,500 pounds strength is developed up to bending point.

58. The temperature at which bending occurs is recorded as the refractory index.

59. Place samples and record in permanent file for future reference.

For the control of slip and glazes in factories making glazed ware, the following method will be found to give excellent results.

1. Prepare materials heavier than is required for actual use.

2. Reduce specific gravity to proper point by adding water.

3. Test viscosity.

4. If too thin add hydrochloric acid, or ammonium chloride.

5. If too thick add sodium carbonate or magnesium sulphate.

Satisfactory values in a plant using compressed air for spraying were found to be:

	Sp. Gr.	Viscosity
Slip	1.80	.160 Poise
Glaze	2.20	.120 Poise

Tests similar to the above are applicable to casting slips and other work of the same general nature. Other chemicals than those noted are frequently used for the purpose indicated. Temperature is usually of little importance in this work, and generally is not noted if nearly normal.

Specific gravity is determined by completely filling a glass-stoppered bottle, inserting the stopper, and washing the surplus material from the sides. The bottle is weighed and the ordinary calculations employed. When these have been once made, only the total weight of the filled bottle need be noted on subsequent tests.

A. S. T. M. Standards

The American Society for Testing Materials has adopted the following standard methods of ultimate chemical analysis of refractory materials, which is suitable to all clay analysis.

Prefatory Note.—It will be understood that the making of a complete silicate analysis is a difficult procedure requiring a wide knowledge of the chemistry involved in the operations, and a thoro training in carrying out the work. A skilled analyst of good training is therefore required to do the work. The descriptions here given cover the vital points of procedure, but frequent reference in regard to the details of the various manipulations must be made to Bulletin No. 422, United States Geological Survey on "Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand also, to "Treatise on the Ceramic Industries," Vol. 1 (1913), by J. W. Mellor and to similar publications.

1. General Considerations

1. The sample shall be crushed in a hardened tool-steel mortar, using a pestle of the same sort. Fine grinding shall be done in an agate mortar, either by hand, or by a mechanical sample grinder of the McKenna, Carling or similar type, so constructed as to prevent the introduction of impurity.

2. Moisture shall be determined in the sample in its ordinary air-dried condition, and all other percentage compositions shall be calculated to a moisture-free basis. Whenever a sample is weighed out for any determination, a moisture determination shall also be made. If preferred, the sample may be dried in a weighing bottle, from which the required samples shall be weighed out.

3. In all cases, check determinations shall be made, and the results shall be redetermined if satisfactory checks are not obtained. It shall be considered satisfactory if the differences between check determinations do not exceed the following limits:

For silica or other constituent amounting to 30 per cent or over	0.3 per cent
For alumina or other constituent amounting to 10-30 per cent	0.2 per cent
For any other constituent amounting to under 10 per cent	0.1 per cent

These figures are stated in terms of the whole sample as 100 per cent.

II. Solutions Required

4. The acids referred to as concentrated shall be of approximately the following specific gravities:

Hydrochloric Acid (HCl)	1.20
Sulfuric Acid (H_2SO_4)	1.84
Nitric Acid (HNO_3)	1.42

5. Dissolve 1.5 g. of ammonium carbonate in 50 cc. of cold water.

6. Dissolve 107 g. of NH_4Cl in 1000 cc. of warm water.

7. Neutralize 20 cc. of concentrated HNO_3 with NH_4OH and dilute to 1000 cc. Test with litmus; the solution shall not be acid.

8. Dissolve 1 g. of ammonium oxalate in 50 cc. of water, heating gently.

9. The strength of the final standard titania solution shall be 1 cc.=0.0001 g. TiO_2. To prepare the solution weigh out in a platinum crucible an amount of potassium titanium fluoride (K_2TiF_6) sufficient to make from ½ to 1 liter of "stock solution" in which 1 cc.=0.001 g. TiO_2. Evaporate several times with H_2SO_4 without taking to dryness, thus driving out all fluorine. Take up the residue with water containing enough H_2SO_4 to make at least 5 per cent. of the solution, when finally diluted to the standard solution strength. To standardize the stock solution take out two 50-cc. portions, dilute, boil and precipitate with ammonia. Filter, wash with hot water until free from alkali, ignite, blast and weigh. The duplicate should check very closely. From the weight of titania thus determined calculate the strength of the stock solution. The standard solution to be used is obtained from the stock solution by diluting until 1 cc.=0.0001 g. (TiO_2).

10. Dissolve about 0.4 g. (a little less) of $KMnO_4$ in a liter of water and check against an iron solution of known purity and strength. Dilute the solution until 1 cc.=0.001 g. Fe_2O_3.

The ordinary chemical iron wire is not sufficiently pure for this use. If preferred the solution may be standardized against sodium oxalate, a pure form of which is prepared especially for such work by the U. S. Bureau of Standards, Washington, D. C.

III. Methods

Moisture

11. To determine moisture, heat approximately 1 g. of the sample at a temperature not under 105 nor over 110 deg. C., to constant weight.

Loss on Ignition

12. To determine loss on ignition, heat about 1 g. of the sample over a blast lamp or in an electric furnace at 900 to 1000 deg. C., to constant weight. Ignition loss may be determined in the sample from which the moisture has been removed. The percentage of ignition loss is calculated to a moisture-free basis.

Silica

13. To determine silica, weigh out approximately 0.5 g. of the sample and mix with 5 g. of Na_2CO_3. Put a little Na_2CO_3 in the bottom of the crucible before introducing the mixture, and then cover the mixture with a little more Na_2CO_3. Fuse over a Meker burner or blast lamp until complete solution is obtained. Cool the fusion and as it solidifies, rotate the crucible to spread the mass up the side walls. Dissolve the fusion in about 100 cc. of water in a platinum or porcelain evaporating dish. Add about 20 cc. of concentrated HCl, introducing it slowly by means of a pipette, keeping the dish covered with a watch glass. Evaporate to dryness and heat until the fumes of HCl are gone. Add about 5 cc. of concentrated HCl and 30 to 40 cc. of water. Warm on a water bath for 10 to 15 minutes and break up the lumps. Decant the clear liquid onto a filter paper and collect the filtrate in a 400-cc. beaker. Add more HCl and water to the evaporating dish warm again and decant. Repeat this a third time.

Finally transfer the contents of the dish to the filter paper. Wash with cold water until silver nitrate shows no chlorides to be left. Transfer the filtrate to the original evaporating dish, evaporate again to dryness, take up with a little HCl and water, transfer to a new filter paper and wash as before. Transfer both silica precipitates to a platinum crucible. Ignite carefully over a Bunsen flame until the filter paper is burned off, then blast for about 30 minutes; cool and weigh. Repeat blasting for 5 minutes, weigh again and repeat until constant weight is obtained.

To the residue in the crucible add about 5 cc. of water and 5 drops of H_2SO_4. Add HF drop by drop at first, and then slowly until the crucible is almost one-half filled. Warm on a hot plate until almost dry, add 2 or 3 cc. more of HF and evaporate to dryness. Heat the crucible to bright redness and then blast for 5 minutes. Cool and weigh and repeat blasting to constant weight. The loss in weight from the original silica residue represents the actual silica content (SiO_2), except for that part of silica which is later recovered from alumina, etc. The residue from the HCl evaporation is left in the crucible and the total precipitate of alumina, etc., is added to this same crucible in which it is ignited and weighed.

Alumina

14. Regarding the determination of alumina, reference should be made to Scientific Paper No. 286 of the U. S. Bureau of Standards by Dr. Blum on "Determination of Alumina as Oxide."

To determine alumina, to the filtrate from the silica determination, add about 10 cc. of NH_4Cl solution and heat to boiling. Then add NH_4OH very slowly and with constant stirring until there is a slight excess. The NH_4OH must be free from CO_2. Filter hot and rapidly, and wash four times by decantation with hot solution of ammonium nitrate. Carefully wash the precipitate from the filter paper into a beaker, using hot water. Dissolve the precipitate in hot dilute HCl. Repeat the precipitation with NH_4Cl and NH_4OH. Decant four times as before, using hot ammonium nitrate. Transfer to the filter paper and wash with hot ammonium nitrate until the washings are free from chlorides when tested by silver nitrate. Evaporate the filtrate nearly to dryness, add a little NH_4OH and continue the evaporation. Keep the solution alkaline to coagulate any iron and aluminum hydroxides. Transfer the precipitate to a filter paper and wash thoroly. Transfer the moist filter paper to the platinum crucible containing the residue from the silica. Burn off the filter paper and blast the precipitate. Repeat blasting and weighing to a constant weight.

Iron Oxide.

15. To determine iron oxide, fuse the ignited alumina precipitate with about six times its weight of potassium pyrosulfate or potassium bisulfate. Avoid sputtering. Heat carefully to redness and continue heating until the residue is all dissolved. Cool. Dissolve in warm water and add about 10 cc. of dilute H_2SO_4 (1:5). Evaporate to a small volume. Then heat to a higher temperature until copious fumes of H_2SO_4 are evolved. Sufficient H_2SO_4 should be present to form a pasty mass when cooled. Take up with water, filter off, wash, ignite and weigh the silica as before and evaporate with HF as before. The loss in weight is extra silica to be added to the original silica determination and subtracted from the alumina. Fuse the residue with a little potassium pyrosulfate or potassium bisulfate, and add the solution of this cake to the main solution. Transfer the total filtrate to a 250-cc. graduated flask and dilute to 250 cc., mixing thoroly. Draw off 50 cc. of this solution and reserve for titania determination. Pass the remaining 200 cc. through a Jones reductor, or otherwise reduce the solution with pure zinc and H_2SO_4. To the solution add 3 cc. of 10-per-cent $CuSO_4$ solution and titrate with standard $KMnO_4$ solution (1 cc. equivalent to 4.001 g. Fe_2O_3), until a faint pink tinge is seen. If Jones reductor or similar apparatus is used, subtract the $KMnO_4$ equivalent, which has previously been determined on blank samples run thru the apparatus. From the result, calculate the iron as Fe_2O_3.

Titania

16. To determine titania, place in a small Nessler tube the 50 cc. of filtrate previously set aside for titania determination, and fill the tube up to the graduation mark. Add 1 cc. of H_2O_2 (free from fluorine) and shake well. The color of this solution is now compared in any standard color comparator with the color of a known standard solution, preferably of such strength that 1 cc. equals 0.0001 g. of titanium dioxide (TiO_2). To make the comparison, put 10 cc. of this standard solution into a second small Nessler tube and dilute with water from a burette until the color is matched. Note the amount of water added and calculate the percentage of TiO_2 in the sample.

Lime

17. To determine lime, evaporate the filtrate from the alumina precipitation to about 250 cc. While still boiling add about 5 cc. of acetic acid. Meanwhile, dissolve about 1 g. of oxalic acid in a little hot water and add to the solution. In about 5 minutes add a slight excess of NH_4OH and boil until precipitation is complete. Cool thoroly and filter. Wash three times by decantation with dilute NH_4OH (1:10) or a 1-per-cent. solution of ammonium oxalate. Dissolve the precipitate by adding about 50 cc. of dilute HNO_3 (1:5). Again add a slight excess of NH_4OH and a few drops of oxalic-acid solution. Boil well and let stand a couple of hours to cool. Filter and wash as before. Transfer the precipitate to a platinum crucible, carefully burn off the paper and ignite over a blast lamp for about 10 minutes. Cool and weigh quickly. Repeat the blasting to constant weight. The increase in weight of crucible is calcium oxide.

Magnesia

18. To determine magnesia, add to the filtrate from lime precipitation about 2 g. of sodium-ammonium-phosphate dissolved in 15 cc. of water. Stir vigorously and while stirring add drop by drop about one-third of the volume of the solution of NH_4OH. Let stand 12 to 24 hours. Filter and wash the precipitate with dilute NH_4OH (1:10). Discard the filtrate. Wash the precipitate until the washings show no discoloration when tested with silver nitrate. Redissolve the precipitate in warm dilute HNO_3 (1:5), using about 50 cc., and collect in a beaker. Precipitate and wash as before. Collect the precipitate on a Gooch asbestos crucible. Dry slowly and then heat over a Meker burner for about 10 minutes; cool and weigh. Re-ignite to constant weight.

The $Mg_2P_2O_7$ is never pure, being contaminated by small amounts of calcium, barium, aluminum, iron, manganese, etc., but in the analysis of refractories this error is negligible, and correction for these impurities is not required unless previously agreed upon.

Alkalies

19. To determine alkalies, the J. Lawrence Smith method shall be used. Weigh out about 0.5 g. of the sample and mix well with 0.5 g. of NH_4Cl and 3 g. of $CaCO_3$. Transfer to a platinum crucible, placing about 0.5 g. of $CaCO_3$ in the bottom of the crucible and a similar amount over the top of the mixture. Heat gently over a low flame for about 15 minutes to volatilize NH_4Cl. Then raise the temperature until the lower three-quarters of the crucible is dull red. Hold this temperature for about one hour. Cool, take up with about 50 cc. of water and heat over a water bath, adding water to replace that lost by evaporation. Break up any lumps with a small pestle. Decant the clear liquid thru a filter paper and wash four times by decantation. Then transfer the residue to the filter. Wash until silver nitrate shows only a very faint turbidity. To the filtrate add NH_4OH and ammonium carbonate and heat to boiling. Filter and again digest the precipitate with NH_4OH and ammonium carbonate. Filter and allow the filtrate to collect with the previous filtrate, then evaporate to dryness in a platinum or porcelain dish. Remove ammonium salts by gentle ignition in a moving flame. Treat with water and remove the last trace of lime by adding ammonium oxalate to the boiling solution and let stand over night. Filter, evaporate to dryness, ignite gently and allow to cool. Then moisten the residue with HCl, evaporate again to dryness, ignite gently and weigh. Dissolve in water. Ignite and weigh any insoluble residue, deducting this from the alkali chlorides.

Dilute the solution of the mixed chlorides and add hydro-chloroplatinic acid in amount equal to 0.3 cc. more than would be necessary if all chlorides were present as NaCl. Evaporate to a syrupy consistency. Cool and treat with a few cubic centimeters of 80-per-cent. ethyl alcohol. Stir and decant thru a weighed Gooch crucible. Treat again with 80-per-cent. alcohol and decant. Repeat washing and decantation until the alcohol leaving the Gooch crucible is colorless and the precipitate appears golden yellow, not orange. Transfer the precipitate to the Gooch crucible, wash with 80-per-cent. alcohol about six times and dry at 130 deg. C. to constant weight. This residue is potassium chloroplatinate.

The oxides are calculated as follows:

Weight of potassium chloroplatinate $\times 0.3068 = KCl$.
Weight of potassium chloroplatinate $\times 0.1941 = K_2O$.
Total chlorides $- KCl = NaCl$.
$NaCl \times 0.5303 = Na_2O$.

142—COAL, HOW TO SELECT

The American Society for Testing Materials has adopted the following standard method for sampling coal.

It is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the standard methods described herein, for if the sampling is improperly done, the sample will be in error, and it may be impossible or impracticable to take another sample; but if an analysis is in error, another analysis can easily be made of the original sample.

Gross samples of the quantities designated herein must be taken whether the coal to be sampled consists of a few tons or several hundred tons, because of the following cardinal principle in sampling coal that must be recognized and understood; that is, the effect of the chance inclusion or exclusion of too many or too few pieces of slate or other impurities in what, or from what, would otherwise have been a representative sample will cause the analysis to be in error accordingly, regardless of the tonnage sampled. For example, the chance inclusion or exclusion of 10 lb. too much or too little of impurities in or from an otherwise representative sample of 100 lb. would cause the analysis to show an error in ash content and in heat units of approximately 10 per cent., whereas for a 1,000-lb. sample, the effect would be approximately only 1 per cent., being the same whether the sample is collected from a 1-ton lot or from a lot consisting of several hundred tons.

When this method of sampling is to be employed as a part of any contract or agreement, the following provisions shall be specifically agreed to by the parties to such contract or agreement:

(a) The place at which the coal is to be sampled (see Section 1);

(b) The approximate size of the sample required when the standard conditions do not apply (see Section 3);

(c) The number of samples to be taken or the amount of coal to be represented by each sample when the standard conditions do not apply (see Section 4).

I. For All Determinations Except Total Moisture

1. The coal shall be sampled when it is being loaded into or unloaded from railroad cars, ships, barges, or wagons, or when discharged from supply bins, or from industrial railway cars, or grab buckets, or from any coal-conveying equipment, as the case may be. If the coal is crushed as received, samples usually can be taken advantageously after the coal has passed thru the crusher. Samples collected from the surface of coal in piles or bins, or in cars, ships or barges are generally unreliable.

2. To collect samples, a shovel or specially designed tool, or mechanical means shall be used for taking equal portions or increments. For slack or small sizes of anthracite, increments as small as 5 to 10 lb. may be taken, but for run-of-mine or lump coal, increments should be at least 10 to 30 lb.

3. The increments shall be regularly and systematically collected, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. The standard gross sample shall not be less than 1,000 lb., except that for slack coal and small sizes of anthracite in which the impurities do not exist in abnormal quantities or in pieces larger than ¾ in., a gross sample of approximately 500 lb. shall be considered sufficient. If the coal contains an unusual amount of impurities, such as slate, and if the pieces of such impurities are very large, a gross sample of 1,500 lb. or more shall be collected. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as is contained in the coal sampled. When coal is extremely lumpy, it is best to break a proportional amount of the lumps before taking the various increments of a sample. Provision should be made for the preservation of the integrity of the sample.

4. A gross sample shall be taken for each 500 tons or less or in case of larger tonnages, for such quantities as may be agreed upon.

TABLE I.

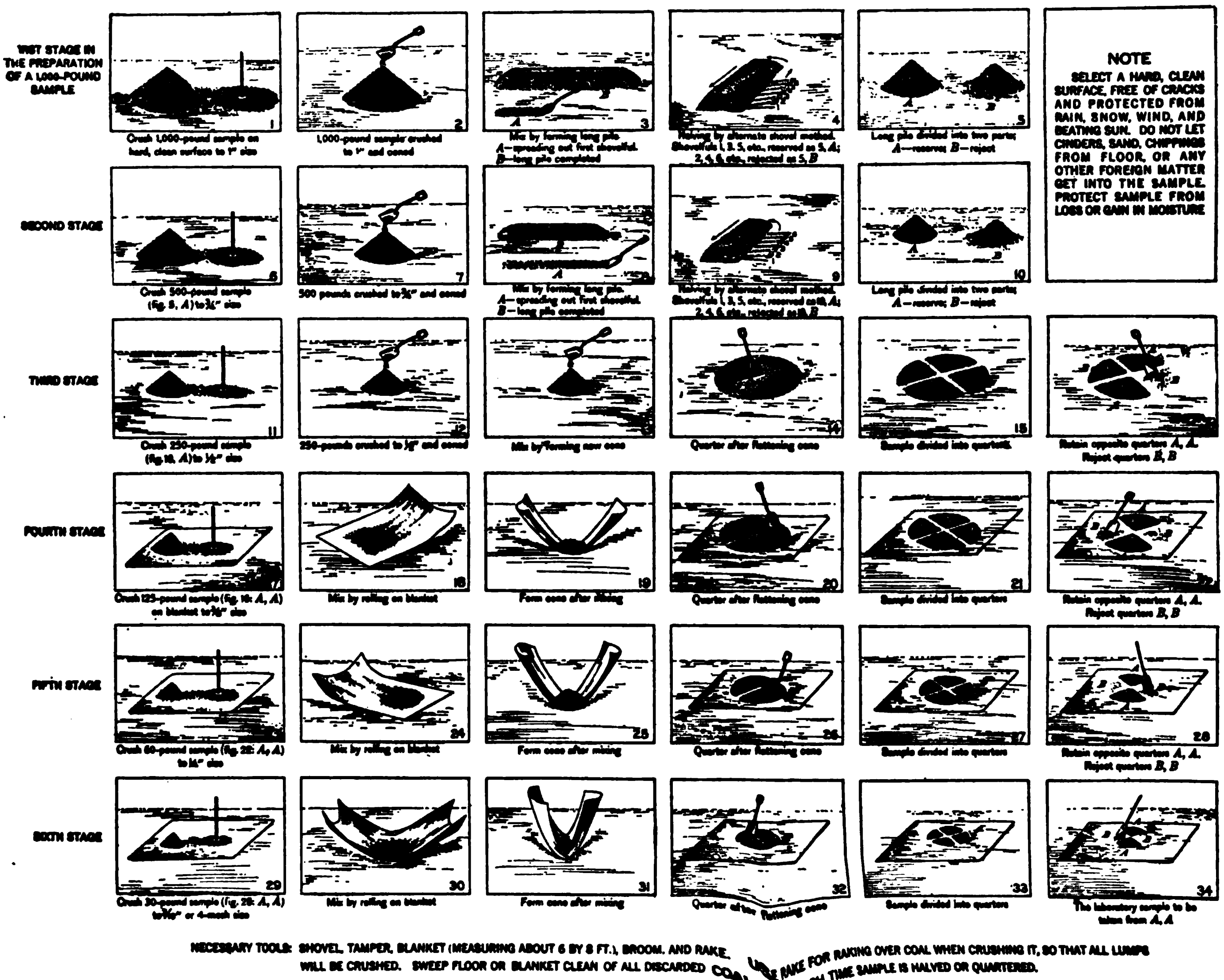
Weight of Sample to be Divided, lb.	Largest Size of Coal and Impurities Allowable in Sample before Division, in.
1,000 or over	1
500	¾
250	½
125	⅜
60	¼
30	3/16 or 4-mesh screen

5. After the gross sample has been collected, it shall be systematically crushed, mixed, and reduced in quantity to convenient size for transmittal to the laboratory. The sample may be crushed by hand or by any mechanical means, but under such conditions as shall prevent loss or the accidental admixture of foreign matter. Samples of the quantities indicated in Table I shall be crushed so that no pieces of coal and impurities will be greater in any dimension, as judged by eye, than specified for the sample before division into two approximately equal parts.

The method of reducing by hand the quantity of coal in a gross sample shall be carried out as prescribed in Section 6, even should the initial size of coal and impurities be less than indicated in Table I.

6. The progressive reduction in the weight of the sample to the quantities indicated in Table I shall be done

METHOD OF PREPARING A SAMPLE OF COAL BY HAND


FIRST STAGE IN THE PREPARATION OF A 1,000-POUND SAMPLE
1
Crush 1,000-pound sample on hard, clean surface to 1" size
2
1,000-pound sample crushed to 1" and coned
3
A
Mix by forming long pile. A—spreading out first shovelful. B—long pile completed
4
Halving by alternate shovel method. Shovelfuls 1, 3, 5, etc., reserved as 5, A; 2, 4, 6, etc., rejected as 5, B
5
A
B
Long pile divided into two parts; A—reserve; B—reject
SECOND STAGE
6
Crush 500-pound sample (fig. 5, A) to ¾" size
7
500 pounds crushed to ¾" and coned
8
A
Mix by forming long pile. A—spreading out first shovelful. B—long pile completed
9
Halving by alternate shovel method. Shovelfuls 1, 3, 5, etc., reserved as 10, A; 2, 4, 6, etc., rejected as 10, B
10
A
B
Long pile divided into two parts; A—reserve; B—reject
THIRD STAGE
11
Crush 250-pound sample (fig. 10, A) to ½" size
12
250-pounds crushed to ½" and coned
13
Mix by forming new cone
14
Quarter after flattening cone
15
Sample divided into quarters
16
A
B
Retain opposite quarters A, A. Reject quarters B, B
FOURTH STAGE
17
Crush 125-pound sample (fig. 16: A, A) on blanket to ⅜" size
18
Mix by rolling on blanket
19
Form cone after mixing
20
Quarter after flattening cone
21
Sample divided into quarters
22
B
Retain opposite quarters A, A. Reject quarters B, B
FIFTH STAGE
23
Crush 60-pound sample (fig. 22: A, A) to ¼" size
24
Mix by rolling on blanket
25
Form cone after mixing
26
Quarter after flattening cone
27
Sample divided into quarters
28
A
B
Retain opposite quarters A, A. Reject quarters B, B
SIXTH STAGE
29
Crush 30-pound sample (fig. 28: A, A) to 3/16" or 4-mesh size
30
Mix by rolling on blanket
31
Form cone after mixing
32
Quarter after flattening cone
33
Sample divided into quarters
34
A
B
The laboratory sample to be taken from A, A

NOTE

SELECT A HARD, CLEAN SURFACE, FREE OF CRACKS AND PROTECTED FROM RAIN, SNOW, WIND, AND BEATING SUN. DO NOT LET CINDERS, SAND, CHIPPINGS FROM FLOOR, OR ANY OTHER FOREIGN MATTER GET INTO THE SAMPLE. PROTECT SAMPLE FROM LOSS OR GAIN IN MOISTURE

NECESSARY TOOLS: SHOVEL, TAMPER, BLANKET (MEASURING ABOUT 6 BY 8 FT.), BROOM, AND RAKE. USE RAKE FOR RAKING OVER COAL WHEN CRUSHING IT, SO THAT ALL LUMPS WILL BE CRUSHED. SWEEP FLOOR OR BLANKET CLEAN OF ALL DISCARDED COAL AFTER EACH TIME SAMPLE IS HALVED OR QUARTERED.

by the following methods, which are illustrated on page 149.

(a) The alternate-shovel method of reducing the gross sample shall be repeated until the sample is reduced to approximately 250 lb., and care shall be observed before each reduction in quantity that the sample has been crushed to the fineness prescribed in Table I.

The crushed coal shall be shoveled into a conical pile (Figs. 2 or 7, page 149) by depositing each shovelful of coal on top of the preceding one, and then formed into a long pile in the following manner: The sampler shall take a shovelful of coal from the conical pile and spread it out in a straight line (Figs. 3A or 8A) having a width equal to the width of the shovel and a length of 5 to 10 ft. His next shovelful shall be spread directly over the top of the first shovelful, but in the opposite direction, and so on back and forth, the pile being occasionally flattened, until all the coal has been formed into one long pile (Figs. 3B or 8B). The sampler shall then discard half of this pile, proceeding as follows:

Beginning on one side of the pile, at either end, and shoveling from the bottom of the pile, the sampler shall take one shovelful (shovelful No. 1, Figs. 4 or 9) and set it aside; advancing along the side of the pile a distance equal to the width of the shovel, he shall take a second shovelful (shovelful No. 2) and discard it; again advancing in the same direction one shovel width, he shall take a third shovelful (shovelful No. 3) and add it to the first. The fourth (shovelful No. 4) shall be taken in a like manner and discarded, the fifth (shovelful No. 5) retained, and so on, the sampler advancing always in the same direction around the pile so that its size will be gradually reduced in a uniform manner. When the pile is removed, about half of the original quantity of coal should be contained in the new pile formed by the alternate shovelsful which have been retained. (Figs. 5A or 10A show the retained halves, and Figs. 5B or 10B the rejected halves.)

(b) After the gross sample has been reduced by the above method to approximately 250 lb., further reduction in quantity shall be by the quartering method. Before each quartering, the sample shall be crushed to the fineness prescribed in Table I.

Quantities of 125 to 250 lb. shall be thoroly mixed by coning and re-coning (Figs. 12 and 13); quantities less than 125 lb. shall be placed on a suitable cloth, measuring about 6 by 8 ft., mixed by raising first one end of the cloth and then the other (Figs. 18, 24 or 30), so as to roll the coal back and forth, and after being thoroly mixed shall be formed into a conical pile by gathering together the four corners of the cloth (Figs. 19, 25 or 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed vertically down with a shovel, or board, so that after the pile has been quartered, each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (Figs. 14, 20, 26 or 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (BB in Figs. 16, 22, 28 or 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coal remaining shall be successively crushed, mixed, coned, and quartered until the sample is reduced to the desired quantity.

(c) The 30-lb. quantity (Fig. 29) shall be crushed to 3/16-in. or 4-mesh size, mixed, coned, flattened and quartered. The laboratory samples shall include all of one of the quarters, or all of two opposite quarters (Fig. 34), as may be required. The laboratory sample shall be immediately placed in a suitable container and sealed in such a manner as to preclude tampering.

7. Only such mechanical means as will give equally representative samples shall be used in substitution for the hand method of preparation herein standardized.

II. For the Determination of Total Moisture

8. The special moisture sample shall weigh approximately 100 lb., and shall be accumulated by placing a waterproof receptacle with a tight-fitting and waterproof lid small equal parts of freshly taken increments of the standard gross sample. The accumulated moisture sample shall be rapidly crushed and reduced mechanically or by hand to about a 5-lb. quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory without delay.

9. Only when equally representative results will be obtained shall the standard gross sample be used instead of the special moisture sample for the determination of total moisture.

Advantages of Buying Coal on Heat Basis

The bureau of mines mentions the following advantages for buying coal on the basis of heat value or B. t. u.:

(1) The bidders are put on a strictly competitive basis.

(2) The field is broadened for both bidder and purchaser.

(3) The contract specifies an established standard of quality as a basis for adjusting the price.

(4) If other coal must be substituted, there is a standard for settlement.

(5) If coal is uniformly poorer than the standard set, there is a basis for cancellation.

(6) When there is need for preparation at the mine (picking, washing, etc.), the operator, who is largely responsible for variations in the grade of such coal, is stimulated to prepare it better.

(7) The purchaser receives true value for what he buys and pays for.

The important points to cover in a coal contract are the heat value, and the water and the ash contents.

The B.t.u.'s per pound "dry" indicates the number of B.t.u.'s contained in one pound of coal after all moisture has been baked out of it, and is an indication of the maximum possibility of the heating value of the particular sample of coal.

"Net B.t.u.'s for one cent" represents the net amount of heat that one cent will buy, and is obtained as follows: Multiply the number of B.t.u.'s per pound of dry coal by the per cent. of moisture (expressed in decimals); subtract the product so found from the number of B.t.u.'s per pound dry coal; multiply the remainder by 2,000 and divide this product by the contract rate per ton (expressed in cents) plus one-half of the dry ash percentage (expressed in decimals).

One-half of the percentage of dry ash is added to the price before dividing to compensate for the decreased burning efficiency of the coal in the furnace on account of the physical presence of the ash.

Buying Coal on Specifications

The coal companies bidding for the contract guarantee to deliver coal having a certain specified analysis at a certain price, from which the net B.t.u.'s for one cent is figured. This value is then used as the contract guarantee and the dealer offering the largest number of net B.t.u.'s for one cent is awarded the contract. Later, this figure serves as means of checking up your deliveries so that you may know just what you are getting and by making comparisons with the standard value, economy is bound to come for the reason that, if a uniform grade is not being delivered, you can detect it and know just how much it is off and then set about to correct it.

How to Arrive at the Correct Price Per Ton

To give an example, let us assume the analysis of a coal to be as follows:

Per cent. Moisture	Per cent. Dry Ash	B.t.u.'s per lb. Dry Coal	Price
10.00	10.00	13,000	$2.50

The net B.t.u.'s for one cent would then be obtained as follows:

13,000	B.t.u.'s in one lb. of dry coal.
×.10	Moisture expressed in decimals
1,300.00	Number of B.t.u.'s to be corrected for, due to per cent. of moisture, and must be subtracted from B.t.u.'s dry.
13,000	B.t.u.'s dry.
—1,300	B.t.u.'s lost due to moisture in coal.
11,700	B.t.u.'s per lb. of coal as delivered.
11,700	
×2,000	lbs. in one ton
23,400,000	number of B.t.u.'s in one ton of coal analyzing as above.
$2.50	price per ton
.05	one-half of dry ash percentage (expressed in cents) to offset decrease in burning efficiency due to presence of ash.
$2.55	

23,400,000÷255=91,764.8 net B.t.u.'s for one cent.

Inasmuch as the net B.t.u.'s for one cent takes into account the amount of moisture, ash and heat contained in the coal, as well as the price, it therefore furnishes the best basis of comparison between different kinds of coal, because it reduces all coals to the same common denominator, showing at a glance which is the cheapest. This you will find of great value in passing on a number of bids.

This Concern Avoided Two Mistakes

The following table shows a number of different bids received by one concern. If the price only had been taken into consideration the purchaser would have made a mistake, as the lowest price (D) was not the cheapest coal. If the heat in the coal only had been taken into consideration, the purchaser would have made another mistake, as the coal of the highest B.t.u. (A) would not have been the cheapest. As it was, he used the net B.t.u. for one cent and purchased the kind of coal (C) from which he could get the most heat for the money.

Kind of Coal	Per-cent. Mois-ture	Per-cent. Dry Ash	Dry B.t.u.'s	Price	Net B.t.u.'s for One Cent
Pocahontas Run of Mine ...(A)	4.0	5.5	14,957	$3.20	88,992
Yough. Screenings .(B)	6.0	12.2	13,466	2.75	90,067
Carterville Screenings ....(C)	10.5	15.5	12,160	1.65	126,045
Indiana Screenings.(D)	15.0	18.1	11,659	1.60	117,289

Each Delivery is Analyzed

A sample of each car or wagon load of coal delivered to the factory is taken and sent to a concern specializing in coal analysis to be analyzed. In this way a test is obtained on all of the coal delivered, and the price or delivered value, as it is called, which the consumer pays to the coal dealer is determined by the analysis.

Assuming that the contract had been made on the analysis as given above and the coal delivered, analyzed as follows:

Per cent. Moisture	Per cent. Dry Ash	B.t.u.'s per lb., Dry
10.85	11.00	12,850

Then the delivered value would be figured as follows:

12,850 B.t.u.'s Dry
×.1085 Moisture expressed in per cent.

64250
102800
12850

1,394.2250 Number of B.t.u.'s to be corrected for, due to per cent. of moisture
12,850.000 B.t.u.'s Dry
—1,394.225 B.t.u.'s due to moisture

11,455.775 B.t.u.'s per lb. as delivered
×2,000 lbs. in a ton

22,911,550.00÷91,764.8=249.67
—5.50 one-half of dry ash, per cent. expressed in cents.

244.17 ($2.44) Price per ton or delivered value in cents.

The Operation of a Heat Value Contract

The following table illustrates the operation of a heat value contract for a period of thirty days, where the consumer received two cars a day, each car being sampled and a composite analysis made of these samples once each week. The contract specified the following:

Per cent. Moisture	Per cent. Dry Ash	B.t.u.'s Per lb. of Dry Coal	Price	Contract Guarantee Net B.t.u.'s for One Cent
10.5	15.5	12,160	$1.65	126,045

Date	Per cent. Moisture	Per cent. Dry Ash	Dry B.t.u.	Delivered Value
First week...	10.4	14.5	12,320	$1.681
Second week..	10.7	14.1	12,400	1.687
Third week...	11.6	16.8	11,939	1.590
Fourth week..	11.5	16.4	12,019	1.605

6.563÷4=$1.64, (the settling price per ton for the month.)

From the above, it is evident that slight fluctuations in ash and moisture may mean a serious loss in the operation of a plant unless the fuel is purchased on the heat value basis.

In entering upon any contract on this basis, the following points should be covered:

(1) A statement of the amount and character of the coal desired.

(2) Conditions for delivery.

(3) Disposition to be made of the coal if it is outside of the contract.

(4) Correction in price for variation in heating value and in moisture and ash content.

(5) Method of sampling.

(6) By whom analyses are to be made.

145—CONCRETE

Quantities of Materials for Different Mixtures of Concrete to Make One Cubic Yard, or Twenty-Seven Cubic Feet

Proportions			Quantities		
Cement	Sand	Gravel or Stone	Sacks of Cement	Cu. Ft. of Sand	Cu. Ft. of Gravel or Stone
1	1.5		15.5	23.2	
1	2		12.8	25.6	
1	3		9.6	28.8	
1	1.5	3	7.6	11.4	22.8
1	2	3	7	14	21
1	2	4	6	12	24
1	2.5	4	5.6	14	22.4
1	2.5	5	5	12.5	25
1	3	5	4.6	13.8	23
1	3	6	4.2	12.6	25.2
1	3	8			

Proper Mixtures for Various Places

Heavy walls below ground can be made of the 1-3-6 mixture, but if the wall encloses a cellar or basement, which must be kept dry the 1-2.5-5 mixture will be found to be more desirable. Walls above ground should be made of 1-2-4 or 1-2.5-4 mixture and sometimes on account of the constant surplus of water in the soil, it is advisable to use 1-2-3.

The concrete forms should be kept on the fresh concrete as long as possible to prevent sudden drying which may weaken and tend to crack the concrete.

A mixture of 1-1-1 or 1-1-1.5 concrete is often used as the wearing course of floors and driveways subjected to heavy traffic.

There is also cement mortar which is a combination of cement and sand in various proportions for several purposes. A mixture of 1-1.5 is used on the inside of walls and tanks, which must be kept as waterproof as possible. The top course of a two course concrete walk or driveway is generally of the 1-2 mixture.

Reducing the Voids in Concrete

Voids is the term used to designate the spaces between the several components of concrete. If stone and sand each having 50 per cent. voids, be mixed with cement in the following proportions:

Cement, 1 part =0.25 cu. yd.
Sand, 2 parts=0.50 cu. yd.
Stone, 4 parts=1.00 cu. yd.

the resulting concrete will measure something more than one cu. yd. and yet it will contain unfilled voids.

These proportions, however, are not economical. By selecting a sand having a range of sizes or by mixing two or more sands having grains of different sizes, the voids in the sand can be reduced to about 33 per cent. In a similar way the voids in the stone can be reduced to about 35 per cent. We will then have approximately:

Cement, 1 part =0.12 cu. yd.
Sand, 3 parts=0.36 cu. yd.
Stone, 8 parts=1.00 cu. yd.

with results as good as with the 1-2-4 mixture, altho using only half as much cement.

151—CONVEYOR, BELT

The Usual Recommendations for the Various Widths and Plies are:

12" and 14" wide	3 or 4-ply
16", 18" and 20" wide	4 or 5-ply
22", 24" and 26" wide	5 or 6-ply
28" and 30" wide	5, 6 or 7-ply
32", 34" and 36" wide	6, 7 or 8-ply
42" and 48" wide	7, 8 or 9-ply
54" and 60" wide	8 or 9-ply

The life of a conveyor belt is dependent:

On the number of places material is fed to the belt, because wear of the carrying surface is caused by impact.

On the way in which the material is fed, because this impact is greatest when material is not fed in the direction of the travel and at the same speed.

On the carrying of a full load, because only a small portion of the material carried then ever touches the belt, and there is the least wear for a given capacity.

On the length of the belt, because the longer it is, the less frequently any portion comes under the feed chutes, and the less frequently it bends under tension over the pulleys.

On the grade of belt, and the grade and thickness of the cover.

On the abrasive character of the material handled.

On keeping the belts and pulleys clean.

On the proper design, installation and operation of troughing and guide idlers and their proper lubrication.

Table No. 1

Capacities of Horizontal Troughed Belt Conveyors, in Tons Per Hour

(Assuming a continuous and uniform feed to the conveyor)

Carrying Material Weighing 100 lbs. per Cubic Foot

Width of Belt, Inches	Velocity in Feet per Minute										
	100	150	200	250	300	350	400	450	500	550	600
12	21	32	42	53	63	74	85	......	......	......	......
14	27	41	55	68	82	96	110	......	......	......	......
16	37	56	75	93	112	131	150	......	......	......	......
18	52	81	105	131	162	183	210	236	......	......	......
20	65	97	130	162	195	227	260	292	......	......	......
22	77	116	155	193	232	271	310	348	387	......	......
24	95	142	190	237	285	332	380	427	475	......	......
30	150	225	300	375	450	525	600	675	750	825	......
36	210	315	420	525	630	735	840	945	1050	1155	......
42	260	390	520	650	780	910	1040	1170	1300	1430	......
48	390	585	780	975	1170	1365	1560	1755	1950	2145	2340
54	550	825	1100	1375	1650	1925	2200	2475	2750	3025	3300

Table No. 2

Horse Powers Required

For belt conveyors, based on horizontal conveyor 100 feet center to center, carrying material weighing 100 lbs. per cubic foot. For conveyors of other length multiply by

$$\frac{(\text{Length of conveyor in feet})}{(\qquad 100 \qquad)}$$

Width of Belt, Inches	Velocity in Feet per Minute											H. P. to Add For Each Tripper
	100	150	200	250	300	350	400	450	500	550	600	
12	1.6	1.7	1.8	1.9	2.1	2.2	2.3	.....	.....	.....	.....	.5
14	1.6	1.7	1.9	2.0	2.3	2.4	2.6	.....	.....	.....	.....	.5
16	1.7	1.8	2.0	2.1	2.4	2.5	2.8	.....	.....	.....	.....	.75
18	1.7	1.8	2.1	2.3	2.5	2.7	3.0	3.2	.....	.....	.....	1.0
20	1.8	1.9	2.2	2.5	2.7	3.0	3.3	3.8	.....	.....	.....	1.25
22	1.8	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.4	.....	.....	1.50
24	2.1	2.4	3.0	3.5	4.0	4.5	5.2	5.8	6.5	.....	.....	1.75
30	2.7	3.5	4.2	5.3	6.3	7.4	8.4	9.5	10.5	11.6	.....	2.5
36	3.3	4.4	5.8	7.3	8.7	10.2	11.6	13.0	14.5	16.0	.....	3.25
42	4.3	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	.....	4.0
48	5.2	7.9	10.5	13.1	15.8	18.4	21.0	23.6	26.3	29.0	31.5	5.0
54	6.8	10.2	13.6	17.0	20.4	23.8	27.2	30.6	34.0	37.4	40.8	6.0

An average rule which gives some idea of what a belt should do, is: assuming one feed and ⅛" good grade cover, a belt conveyor 100 feet long should handle during its life a tonnage = 500 × the square of the width in inches; 200 feet long, twice as much, etc.

Table No. 4 is based on belt speed 300 ft. per min.; length of conveyor 100 ft.; shaft bearings standard distance apart.

Diameters of drive pulleys and their shafts given in inches (opposite index horse power ratings) are determined as follows:

Table No. 3

Additional Horse Power Required

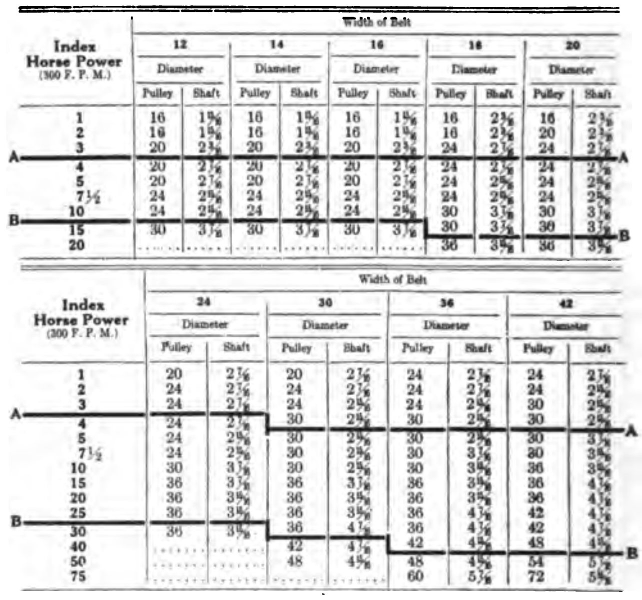
For Inclined Conveyors, to be Added to Horse Power Required for Horizontal Conveyor

The horse powers in these three tables are sufficiently conservative to include first and second counter shafts.

Tons per Hour.	Height Material is Raised (in Feet)												
	5	10	15	20	25	30	40	50	60	70	80	90	100
10	.05	.1	.15	.2	.25	.30	.4	.5	.6	.7	.8	.9	1
15	.075	.15	.22	.3	.37	.45	.6	.75	.9	1.05	1.2	1.35	1.5
20	.1	.2	.3	.4	.5	.6	.8	1.0	1.2	1.4	1.6	1.8	2
30	.15	.3	.45	.6	.75	.9	1.2	1.5	1.8	2.1	2.4	2.7	3
40	.2	.4	.6	.8	1.0	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4
50	.25	.5	.75	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5
75	.37	.75	1.12	1.5	1.87	2.25	3.0	3.75	4.5	5.25	6.0	6.75	7.5
100	.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10
125	.63	1.25	1.88	2.5	3.13	3.75	5.0	6.25	7.5	8.75	10.0	11.25	12.5
150	.75	1.5	2.25	3.0	3.75	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15
200	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20
250	1.25	2.5	3.75	5.0	6.25	8.0	10.5	13.0	15.5	18.0	20.5	23.0	25
300	1.5	3.0	4.5	6.0	7.5	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30
400	2.0	4.0	6.0	8.0	10.1	12.1	16.1	20.2	24.2	28.2	32.2	36.3	40.3
500	2.5	5.0	7.5	10.0	12.5	15.1	20.1	25.2	30.2	35.2	40.2	45.3	50.3
750	3.7	7.4	11.1	14.8	18.5	22.2	29.6	37.0	44.4	51.8	59.2	66.6	74
1000	5	10	15	20	25	30	40	50	60	70	80	90	100

Table No. 4

Diameters of Drive Pulleys and Their Shafts Dimensions in Inches



Index Horse Power (300 F. P. M.)	Width of Belt									
	12		14		16		18		20	
	Diameter		Diameter		Diameter		Diameter		Diameter	
	Pulley	Shaft	Pulley	Shaft	Pulley	Shaft	Pulley	Shaft	Pulley	Shaft
1	16	1 15/16	16	1 15/16	16	1 15/16	16	2 3/16	16	2 3/16
2	16	1 15/16	16	1 15/16	16	1 15/16	16	2 3/16	20	2 3/16
3	20	2 3/16	20	2 3/16	20	2 3/16	24	2 7/16	24	2 7/16
A										
4	20	2 7/16	20	2 7/16	20	2 7/16	24	2 7/16	24	2 7/16
5	20	2 7/16	20	2 7/16	20	2 7/16	24	2 11/16	24	2 11/16
7½	24	2 15/16	24	2 15/16	24	2 15/16	24	2 15/16	24	2 15/16
10	24	2 15/16	24	2 15/16	24	2 15/16	30	3 7/16	30	3 7/16
B										
15	30	3 7/16	30	3 7/16	30	3 7/16	30	3 7/16	30	3 7/16
20	......	......	......	......	......	......	36	3 15/16	36	3 15/16

Index Horse Power (300 F. P. M.)	Width of Belt							
	24		30		36		42	
	Diameter		Diameter		Diameter		Diameter	
	Pulley	Shaft	Pulley	Shaft	Pulley	Shaft	Pulley	Shaft
1	20	2 7/16	20	2 7/16	24	2 7/16	24	2 7/16
2	24	2 7/16	24	2 7/16	24	2 7/16	24	2 15/16
3	24	2 7/16	24	2 15/16	24	2 15/16	30	2 15/16
4	24	2 7/16	30	2 15/16	30	2 15/16	30	2 15/16
5	24	2 15/16	30	2 15/16	30	2 15/16	30	3 7/16
7½	24	2 15/16	30	2 15/16	30	3 7/16	30	3 15/16
10	30	3 7/16	30	2 15/16	30	3 15/16	36	3 15/16
15	36	3 7/16	36	3 7/16	36	3 15/16	36	4 7/16
20	36	3 15/16	36	3 15/16	36	3 15/16	36	4 7/16
25	36	3 15/16	36	3 15/16	36	4 7/16	42	4 7/16
30	36	3 15/16	36	4 7/16	36	4 7/16	42	4 7/16
40	......	......	42	4 7/16	42	4 15/16	48	4 15/16
50	......	......	48	4 15/16	48	4 15/16	54	5 7/16
75	......	......	......	......	60	5 7/16	72	5 15/16

Select width of belt from Table No. 1 providing sufficient width for largest pieces handled.

Use horse power in Table 2, listed for the width, at 300 ft. per min.

Multiply this by $\frac{(\text{Length of conveyor in feet})}{(\qquad 100 \qquad)}$

This gives index horse power rating for the item of length.

If there is a tripper, add listed power from Table 2.

If there is an incline, add from Table 3 the power required for the height (in feet), multiplying it by 300, and dividing the result by the actual belt speed in feet per minute.

The determinations for length, tripper and incline, added together, give the final index horse power to be used.

Corresponding diameters of pulley and shaft are given in column headed with width of belt, in Table 4.

If the figures are above line A-A, a plain crown face pulley without rubber cover will be sufficient.

All pulleys below line A-A should have rubber cover, and drives below line B-B should use an idler drive.

Capacity and Speed. A fair average speed of belt conveyors is 300 feet per minute. This should be a maximum for belts under 16" in width; up to 24" it may increase to 450 feet per minute; and to a speed of 600 feet per minute for 36" and wider. Like all other conveyors, belts should carry their full load. There is no economy in running at a given speed with only half load; it is better to reduce the speed and run the belt full. See capacities in Table 1.

Materials Handled. The width of the belt must frequently be determined by the size of pieces of material handled, rather than by the actual carrying capacity in pounds or cubic feet. The following are recommended as the maximum sizes of pieces to be handled on the different widths of belt:

12" belt, 2" pieces; 18" belt, 4" pieces; 24" belt, 8" pieces; 30" belt, 14" pieces; 36" belt, 18" pieces; 48" belt, 24" pieces.

Movement of take-ups should not be less than one per cent. of conveyor centers for horizontal conveyors, and not less than 1¼ per cent. for inclined conveyors.

Spacing of Carrying Idlers

Size of Conveyor	Material Less than 30 lbs. per cubic foot	Material 30 lbs. to 60 lbs. per cubic foot	Material 60 lbs. to 120 lbs. per cubic foot
12" to 18" Belt	5'-6" to 6'-6" Average 6'-0"	4'-6" to 5'-6" Average 5'-0"	4'-0" to 5'-0" Average 4'-6"
20" to 28" Belt	5'-0" to 6'-0" Average 5'-6"	4'-6" to 5'-6" Average 5'-0"	4'-0" to 5'-0" Average 4'-6"
30" to 48" Belt	4'-6" to 5'-6" Average 5'-0"	4'-0" to 5'-0" Average 4'-6"	3'-6" to 4'-6" Average 4'-0"

Minimum spacing is used for conveyors carrying proportionately large pieces, and full load.

Maximum spacing is used for conveyors carrying small material, and not fully loaded.

Return Idlers

12" to 30" belt	12 ft. centers
32" to 48" belt	10 ft. centers

Guide Idlers for Carrying Run

12" to 16" belt	30 ft. centers
18" to 28" belt	35 ft. centers
30" to 48" belt	40 ft. centers

Guide idlers should not be placed less than 20 ft. from head and tail pulleys.

Guide idlers should not be used for part of conveyor transversed by tripper.

Guide idlers for return run are not needed for conveyors of less than 150 ft. centers, but for longer conveyors, space them about 80 ft. centers.

We recommend a minimum speed of 300 ft. per minute for belt conveyors using tripper. This speed is needed in order to discharge properly over tripper pulley.

Discharge plows are frequently used in connection with flat belts. In such a case the speed of belt should be kept low—not to exceed 150 ft. per minute.

Example of the Use of the Tables

Carrying shale with maximum pieces of ten inch cubes, and 135 tons per hour. This will average about 100 pounds per cubic foot. Suppose the belt has centers 200 feet apart, is set on an incline of 20 degrees or a 68 ft. raise, is loaded at one point and discharged over head pulley.

From the information given above we will try on a 30 inch troughed belt running 200 feet per minute.

Actual h. p. required for length (Table No. 2) 30 inch belt, 200 feet per minute $4.2 \times \frac{200}{100} = 8.4$

for incline (Table No. 3) and lift about 9.6

Total 18.0

We then determine the index horse power and from Table No. 4 find the size of shaft and drive pulley. To find the index horse power we take for length (Table No. 2—30 inch belt, 300 f.p.m.) $6.3 \times \frac{200}{100} = 12.6$

for incline (9.6 actual h. p. as figured above) $9.6 \times \frac{300}{200} = 14.4$

Total index horse power 27.0

Table No. 4 shows under column for 30 inch belt and on line for 30 index h. p. that the proper pulley is 36 inch rubber covered and the proper size of shaft is 4 7/16 inch.

Tension in Conveyor Belt

Tension is figured according to the following formulas:

For plain cast iron pulley $\dfrac{\text{h. p.} \times 55{,}000}{\text{Belt speed in feet per min.}}$

For rubber-covered pulley $\dfrac{\text{h. p.} \times 45{,}000}{\text{Belt speed in feet per min.}}$

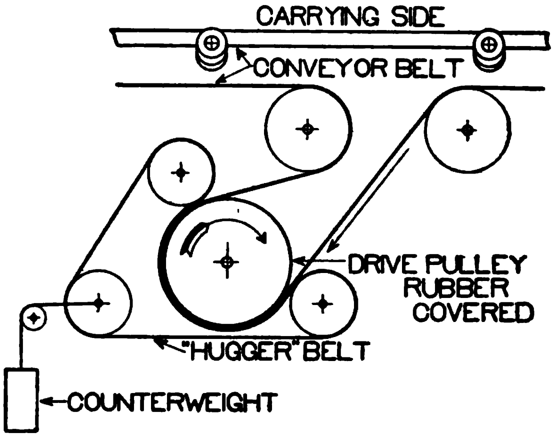
The ply of a belt is determined by using an average tension of 20 pounds per ply per inch of width.

In the installation under consideration

$$\text{tension} = \frac{18 \times 45{,}000}{200} = 4{,}050 \text{ pounds.}$$

$$\text{Ply of belt} = \frac{4{,}050}{20 \times 30} = 6.8$$

This shows that a 7-ply belt should be used.



Sketch Showing How Patented "Hugger" Drive for Conveyors Increases Grip Without Adding to Tension.
Courtesy of the Link-Belt Co.

General Rules

The following general rules, which embody the best in belt conveyor practice, have been collected for the convenience of the engineer who has not the time to go further into details.

Width of Belts

For clay use at least four times the uniform size of material handled plus six inches or four times the average sized pieces plus six inches where such pieces are about 70 or 80 per cent. of the whole—with the width of the belt in no case to be less than twice the largest pieces handled plus eight inches, where such pieces do not exceed 10 per cent. in uniform distribution of all the material carried.

The capacity in tons per hour of materials such as clay, weighing 100 pounds per cubic foot and carried over three or five pulley troughing carriers is approximately 16 per cent. of the square of the number of inches in the width of the belt, for each 100 feet of belt speed per minute.

The maximum speed of belts should be approximately 250 feet per minute for a ten inch belt, plus 10 feet per minute for each additional inch of belt width. Slow speed equals 150 feet per minute.

The horse power required amounts to approximately two per cent. of the number of tons per hour carried for each 100 feet of horizontal belt length and one per cent. additional for each ten feet rise of incline. This horse power should be increased at the belt five per cent. for each driving reduction thru chain, belting or cut gears and ten per cent. for each reduction thru rough gears to obtain the final horse power at line shaft, motor or engine.

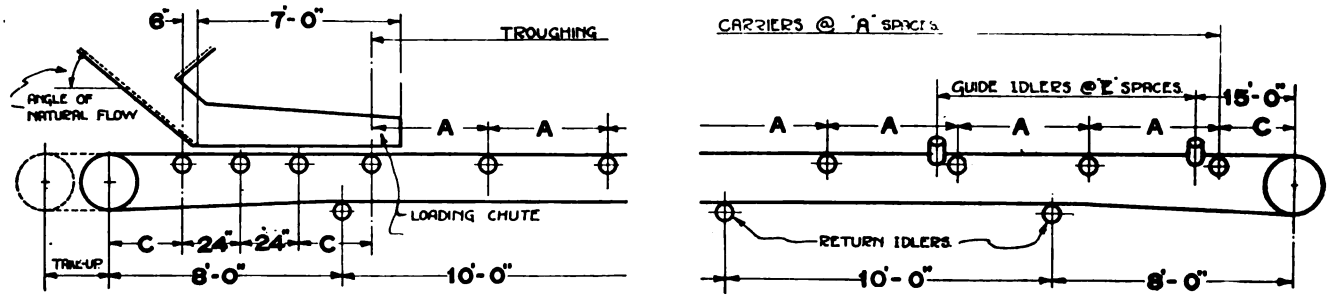
The proper flexibility in belts for troughing carriers is one ply for each four or five inches of belt width, with 12 inch- 3 ply as a minimum and 48 inch- 8 ply as a maximum in ordinary service.

The ultimate strength of the average rubber belt is 360 pounds per inch width of each ply, with a safe tension of 30 pounds thereby using a safety factor of 12. The pull required to move a belt over its carriers upon the level is approximately 20 per cent. of the weight of belt plus 19 per cent. of the weight of load upon the belt.

The diameter of the terminal drive pulleys in ordinary good practice is five times the number of belt plies with the diameter of all other pulleys taking 180 degrees wrap four times the number of plies.

Guarding Against the Elements of Wear to a Belt

Wear on belts is caused almost wholly by the impact and slipping of material on the belt as it is picked up at the loading point. Some considerable wear is also caused by the material rearranging its position on the belt between the loading and discharge points. Wear of the belt is therefore greatly reduced by: (a) One loading point, so installed as to insure a steady flow of material to the belt in the same direction and at the same speed of flow as the travel of the belt. Clay should never be allowed to strike the belt vertically and especially if it is hard and has sharp corners like crushed and unground shale and fire clay. (b) Use of long belts whenever possible thereby bringing any one point in the belt less frequently to the loading point. (c) Full loading at all times since the largest cross section of material presents relatively the smallest surface to the belt. Up to the point of fully covering the conveying surface, the life of the belt decreases proportionately with an increase of load. However, after the belt surface has been covered the decrease in life is much smaller as only part of the material carried ever touches the belt. (d) Handling clay, shale, coal, ashes or other material with rough corners and edges, altho the wear due to this feature is small if due care is given to the method by which the material is fed onto the belt.



Standard Spacing of Belt Conveyor Fixtures

How to Prevent Wearing the Edges of a Belt

Proper alignment of carriers is always important in order that the belt may run perfectly true. This may be done by leaving one side of the carriers partly tightened down in place and by then running the conveyor empty, so that any tendency of the belt to run to either side may be corrected by tapping the carriers either forward or backward, until the belt is adjusted to run centrally.

Spacing of Troughing Carriers and Guide Idlers

Width of Belt Inches	A—For Materials		Sorting Belts only	C	E
	Not over 100 lbs. Cu. Ft.	Over 100 lbs. Cu. Ft.			
14–16	5'–0"	4'–6"	....	2'–6"	30'–0"
18–20	4'–6"	4'–0"	....	3'–0"	45'–0"
24–30	4'–0"	3'–6"	3'–6"	3'–0"	45'–0"
36–42	3'–6"	3'–0"	3'–0"	3'–0"	45'–0"
48	3'–6"	3'–0"	2'–6"	3'–0"	....

Neglect in observing this precaution allows the belt to run over the edges of the outside carrier pulleys or against the sides of chutes, etc., thus rapidly wearing the edges of the belt. As a help to maintaining this proper alignment in long belts, guide idlers are often used.

Action of weather is a point to be considered. Rain, snow, ice and especially the sun's rays are detrimental to rubber belts. Therefore, it is always advisable to provide at least a shelter roof over all belts operating in the open.

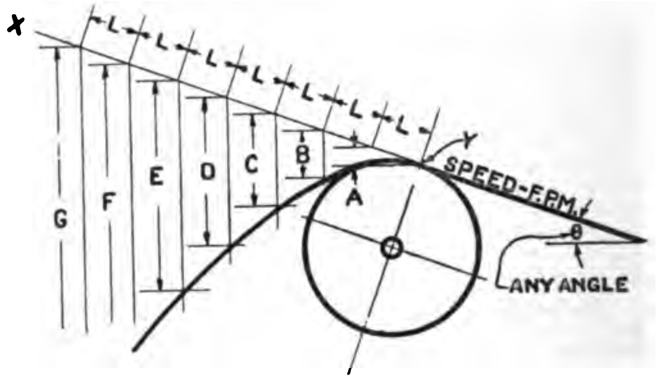
Using a Conveyor with Combined Horizontal and Inclined Sections

It is evident that the travel of the belt under these conditions cannot be made to change from the horizontal to the incline with a sharp or abrupt angle. It has been found that the travel of the belt should follow a curve whose radius is equal to 300 feet or more under ordinary circumstances. Where a gradually increasing load becomes a uniform continuous load a smaller radius may be used and for intermittent but full loading, a radius varying from 500 to 1,000 feet may be required.

The angle of incline should in all cases be about ten or more degrees less than the angle of repose of the material on the belt. Therefore, for the materials ordinarily handled on a belt the maximum incline may be taken at about 20 degrees. Many materials may be carried as high as 21 deg.—23 deg. and some few at 25 deg. Large lumps have a tendency to roll back upon the belt unless they are well intermixed with smaller pieces. Also an intermittent flow of most materials, near 20 degrees has a tendency to cause slipping and often the avalanching of all the material on the incline. Care should therefore be taken to insure a continuous stream, either large or small, of uniform sized or of well intermixed unsized materials.

How to Determine the Discharge Curve

Material as it is discharged from a belt, would continue to travel in the direction and at the speed of the belt except as it is acted upon by two forces, i. e., the force of gravity and the resistance of the air, the latter of which being small is omitted from the following formula. In the handling of any materials, except those which are very light and easily deflected by the resistance of the air or materials which tend to stick to the belt, the discharge from the belt may be determined as follows: In a drawing, to any convenient scale, indicate the discharge pulley and the angle of the belt to the horizontal as shown in the sketch upon this page and continue the direction of the belt in the line "X.Y." On this line from "Y" lay out the equal dimensions L.L.L., etc., where L. in inches equals speed of belt in feet per minute, divided by 100. At the end of the various spaces L.L. drop down vertically the dimensions A. B. C. D., etc., in inches, taken from the table below. Then to find the trajectory or path of the material as it leaves the belt, draw a continuous curve from the point Y thru the bottom of the successive dimensions A. B. C. D., etc.



Discharge Curve of Material from Belt

	Decimal	Fraction		Decimal	Fraction		Decimal	Fraction
A	.43	7/16"	F	17.37	17 3/8"	K	58.37	58 3/8"
B	1.93	1 15/16"	G	23.64	23 5/8"	L	69.47	69 15/32"
C	4.34	4 11/32"	H	30.87	30 7/8"	M	81.53	81 17/32"
D	7.72	7 23/32"	I	39.07	39 1/16"	N	94.55	94 9/16"
E	12.06	12 1/16"	J	48.24	48 1/4"	O	108.54	108 17/32"

At the maximum speed of belts, there is seldom an occasion to obtain the true path of the delivery of material. However, for slow speeds it is often necessary to find the highest point in the face of the pulley at which a discharge chute may be placed where breakage is a consideration.

Courtesy Jeffery Mfg. Co.

154—CONVEYOR, DRAG-PLATE AND BUCKET

The formula used for the power required by drag-plate conveyors is as follows:

$$HP=\frac{AWLS}{1,000}+\frac{BLT}{1,000}+z.$$

in which

HP=the horsepower required at the conveyor drive shaft.

A=constant as per attached table.

B=constant as per attached table.

W=weight of conveyor in pounds per foot of length.

L=distance in feet between centers of head and tail sprockets.

S=speed of conveyor in feet per minute.

T=capacity of conveyor in tons of 2,000 pounds per hour.

z=1 for conveyors up to 100 feet between centers and 2 for longer conveyors.

If the conveyor is composed of portions on different inclines, compute the power for each section separately and add ten per cent. for each change in direction.

155—CONVEYOR, HEAVY DUTY MONORAIL

Capacities of One Make of I-Beam Trolley Type

Capacity in Tons	Standard Size of I-Beam in Inches*	Diameter of Wheel in Inches		Smallest Radius for I-Beam Curve	
		Plain	Geared	Plain	Geared
¼	4	3	....	18	....
½	5	3¾	....	21	....
1	6	4¾	....	21	....
1½	7	5½	5½	30	30
2	8	6½	6½	36	36
3	9	7¼	7¼	42	42
4	10	8¼	8¼	48	48
5	12	10	10	54	54
6	15	10	10	60	60
8	20	12	12	60	60
10	24	13	13	60	60
12	24	13	13	60	60
16	24	18	18	96	96
20	24	18	18	120	120

*Can be altered to suit larger beams.

Courtesy Ford Chain Block Co.

Table for Conveyor, Drag-Plate and Bucket

Degree Angle of Conveyor with Horizontal	A				B Scraper, Apron and Open Top			B V-Buckets and Pivoted Buckets		
	Sliding Blk.	3½" Roller 3¼" Pin	6" Roller 1⅛" Pin	6" Roller 1½" Pin	Anthracite Coal	Bituminous Coal	Ashes	3½" Roller ⅝" Pin	6" Roller 1⅜" Pin	6" Roller 1½" Pin
0	0.030	0.0043	0.0046	0.0050	0.33	0.60	0.54	0.07	0.70	0.083
6	0.030	0.0043	0.0046	0.0050	0.43	0.69	0.63	0.18	0.18	0.19
12	0.030	0.0043	0.0045	0.0049	0.54	0.79	0.73	0.28	0.28	0.29
18	0.029	0.0041	0.0044	0.0048	0.63	0.88	0.82	0.38	0.38	0.39
24	0.028	0.0039	0.0042	0.0046	0.72	0.95	0.90	0.46	0.48	0.49
30	0.026	0.0037	0.0040	0.0043	0.79	1.02	0.97	0.57	0.57	0.58
36	0.025	0.0035	0.0037	0.0040	0.80	1.08	1.03	0.66	0.66	0.66
42	0.023	0.0032	0.0034	0.0037	0.92	1.12	1.07	0.73	0.73	0.74
48	0.020	0.0029	0.0031	0.0033	0.97	1.15	1.11	0.80	0.80	0.81

Apron conveyors are usually built with an inclination of thirty degrees or less.

The power required to drive a V-bucket conveyor is figured from the following formula:

$$HP=\frac{AWL'S}{1,000}+\frac{BLT}{1,000}+\frac{TH}{1,000}+\frac{1}{2}X'$$

in which

A and B=constants same as for drag-plate conveyors.

W=weight of conveyor per ft. or run, lbs.

S=speed of conveyor, ft. per min.

T=capacity of conveyor, tons per hr.

L'=horizontal length of conveyor, ft.

L=total horizontal length traversed by the loaded bucket, ft.

H=total vertical traverse, ft.

X'=number of 90-degree turns in the conveyor.

Courtesy Robins Conveyor Belt Co.

192—DIE, DRAIN TILE

Standard Dimensions in Inches

Size of Tile	Diam. of Core	Bore of Funnel	Thickness of Shell	Size of Tile	Diam. of Core	Bore of Funnel	Thickness of Shell
2½	2.75	3.75	.5	8	8.8	10.4	.8
3	3.3	4.4	.55	9	9.9	11.6	.85
3½	3.85	4.95	.55	10	11.	12.8	.9
4	4.4	5.6	.6	12	13.2	15.2	1.
4½	4.95	6.15	.6	14	15.4	17.6	1.1
5	5.5	6.8	.65	15	16.5	18.8	1.15
6	6.6	8.	.7	16	17.6	20.	1.2
7	7.7	9.2	.75	18	19.8	22.4	1.3

140—COAL HANDLING EQUIPMENT

Points to watch in connection with storage of coal in the open air to be reclaimed later:

(1) The location, size and topography of the available ground.

(2) The capacity of the desired installation.

(3) Cost of the necessary plant.

(4) Cost of maintenance.

(5) Cost of operation.

(6) Amount of breakage due to the handling of the coal.

(7) Length of time the coal will probably be in storage.

(8) The climate at the place of storage.

(9) Adequate facilities for rapidly and economically transferring the coal from cars into storage and for reclaiming it out of storage or for rapidly moving any part of the pile that shows evidence of taking fire.

(10) An adequate supply of water nearby.

(11) Do not pile coal over vents from steam pipes or similar places.

(12) Eliminate fine coal as far as possible from the storage.

(13) Keep the coal as dry as possible.

(14) Avoid too great a height in the pile, not over ten feet for fine coal.

(15) Watch the interior temperature of the pile as much as possible, and either use that part of the pile as soon as possible, or arrange to overhaul that part and flood it.

(16) Store the coal under water if possible.

Using Weathered Coal

The University of Illinois has determined that weathered coal requires a little thinner fire than the same coal unweathered.

158—CONVEYOR, SCREW OR SPIRAL

Capacities Horsepower and Speeds for Different Materials

Ashes, with No Large Lumps at 30 Pounds per Cubic Foot

Diam. of Convr. Inches	Speed R.P.M.	Tons per Hour	Material Flow F.P.M.	HORSEPOWER FOR FOOT CENTERS									
				20	30	40	50	75	100	125	150	175	200
9	50	4	37	.32	.48	.64	.80	1.20	1.60	2.0	2.4	2.8	3.2
12	45	8	45	.64	.96	1.28	1.60	2.40	3.20	4.0	4.8	5.6	6.4
14	43	13	50	1.04	1.56	2.08	2.60	3.90	5.20	6.5	7.8	9.1	10.4
16	40	19	50	1.52	2.28	3.04	3.80	5.70	7.60	9.5	11.4	13.3	15.2

Coal (Screenings or Small Sized Coal) with No Lumps Larger Than 1 Inch

Diam. of Convr. Inches	Speed R.P.M.	Tons per Hour	Material Flow F.P.M.	HORSEPOWER FOR FOOT CENTERS									
				20	30	40	50	75	100	125	150	175	200
9	85	15	64	.75	1.13	1.5	1.88	2.81	3.75	4.69	5.63	6.56	7.5
12	75	30	75	1.50	2.25	3.0	3.75	5.63	7.50	9.38	11.25	13.13	15.0
14	70	40	82	2.00	3.00	4.0	5.00	7.50	10.00	12.50	15.00	17.50	20.0
16	65	60	87	3.00	4.05	6.0	7.50	11.25	15.00	18.75	22.50	26.25	30.0
18	60	80	90	4.00	6.00	8.0	10.00	15.00	20.00	25.00	30.00	35.00	40.0
20	55	100	92	5.00	7.50	10.0	12.50	18.75	25.00	31.25	37.50	43.75	50.0
22	50	125	92	6.25	9.38	12.5	15.63	23.44	31.25	39.06	46.88	54.69	62.5

Ground Clay at 90 lbs. per Cubic Foot. The Capacities Will be Smaller if the Clay or Shale Has Lumps in it

Diam. of Convr. Inches	Speed R.P.M	Tons per Hour	Material Flow F.P.M.	HORSEPOWER FOR FOOT CENTERS									
				20	30	40	50	75	100	125	150	175	200
6	95	5.64	47	.28	.42	.56	.70	1.05	1.40	1.75	2.10	2.45	2.8
9	75	19.75	57	.99	1.49	1.98	2.48	3.71	4.95	6.19	7.43	8.66	9.9
12	70	40.42	70	2.05	3.08	4.10	5.13	7.69	10.25	12.81	15.38	17.94	20.5
14	65	63.92	74	3.20	4.80	6.40	8.00	12.00	16.00	20.00	24.00	28.00	32.0
16	60	90.24	80	4.50	6.75	9.00	11.25	16.88	22.50	28.13	33.75	39.38	45.0
18	55	117.58	83	5.87	8.81	11.74	14.68	22.01	29.35	36.69	44.03	51.36	58.7
20	50	148.46	84	7.47	11.21	14.94	18.68	28.01	37.35	46.69	56.03	65.36	74.7
22	45	179.54	83	8.98	13.47	17.96	22.45	33.68	44.90	56.13	67.35	78.58	89.8

Courtesy Weller Mfg. Co.

168—CRUSHERS, GYRATORY

Table of Dimensions, Weights, Capacities and Power Required

Size of each Feed Opening	Finest Setting		Coarsest Setting		Size of Driving Pulley	Revolutions per Minute	Horse-power of Engine Required	Weight of Crusher Pounds
	Smallest Size of Product	Capacity in Tons 2000 lbs. per Hour	Largest Size of Product	Capacity in Tons 2000 lbs. per Hour				•
Inches	Inches	Tons	Inches	Tons			•	Pounds
5x 20	⅞	4.5	1⅞	8.5	18x 6	600	4- 6	7,000
6x 25	1	6.5	2¼	12.5	20x 8	575	6- 10	10,200
7x 28	1¼	11	2¾	25	22x10	525	10- 15	17,000
8x 34	1½	20	3½	48	28x12	475	12- 20	23,000
10x 40	1¾	30	4¼	75	30x14	450	20- 25	36,500
12x 44	2	50	4½	120	34x16	425	25- 40	48,000
15x 55	2½	80	5	180	40x18	400	45- 70	71,500
18x 68	2¾	110	5½	250	44x20	375	65-100	110,000
21x 76	3	160	6	350	52x20	350	100-140	160,000
24x 84	3½	210	6½	450	52x24	350	115-160	170,000
27x 92	4	260	7	550	52x24	350	130-180	180,000
36x130	5	600	8	1100	66x31	300	200-250	**405,000
42x136	5½	700	9	1300	66x33	300	225-280	**425,000

*The table of horse-power required to drive the crushers is not intended to cover that necessary to drive auxiliary machinery in connection therewith, but in most cases it would be sufficient for simple connections.

**The weights of Mammoth Crushers vary according to the type of hopper used, etc.

**The Mammoth Crushers are made with either single or double discharge spouts as desired.

From Power and Mining Machinery Co.

172—CRUSHERS, TWO ROLL AND COMPOUND

Theory of Angle of Nip

If the rolls C and D (see Fig. 1) of a roll crusher be fed with a sphere of rock E, the tangents to the rolls at tt, the points of contact with the sphere meet below, forming an angle N, which angle is called the angle of nip. This angle may have values from zero degrees, when the space between the rolls is as large as the lump fed, increasing upward until the angle is so large that the rolls cannot nip the fragments.

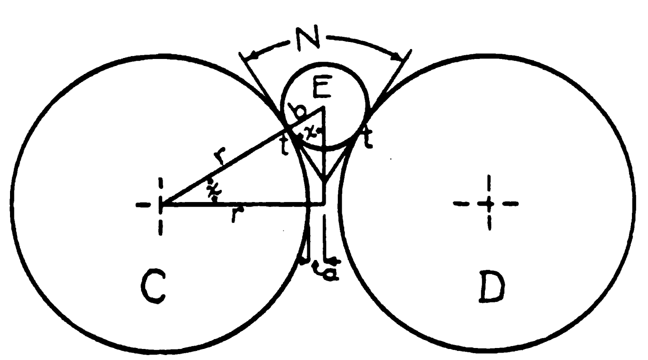


Figure 1. C and D Represent Iron or Steel Rolls and E Represents the Rock to be Crushed. The Angle N is Called the Angle of Nip.

The angle of nip in any case will depend for its value upon the diameter of the rolls, the diameter of the lump fed and the distance apart at which the rolls are set. It is also affected in the following ways: It is diminished by increasing the diameter of the rolls (the space between the rolls being kept constant) by increasing the space between rolls, and by decreasing the size of lumps fed to the rolls.

All relations between the size of material, space between rolls, radius of rolls, and angle of nip can be expressed by a simple formula, which is derived as follows. If b equals the radius of the sphere to be crushed, a equals one-half of the space between the rolls, N equals the angle of nip, and r equals the radius of the roll which is equal to one-half of the diameter, then

$$\frac{r+a}{r+b} = \text{cosine}\ \frac{N}{2}.$$

To effect a reduction, the friction F (see Fig. 2) between the sphere and rolls must equal Ku, where K is the force of the reaction and u is the coefficient of friction. In terms of a force system as represented in the diagram, the component F cos x tends to draw the clay between the rolls, while K sin x tends to push the sphere out, and hence acts in opposite direction to the force F cos x.

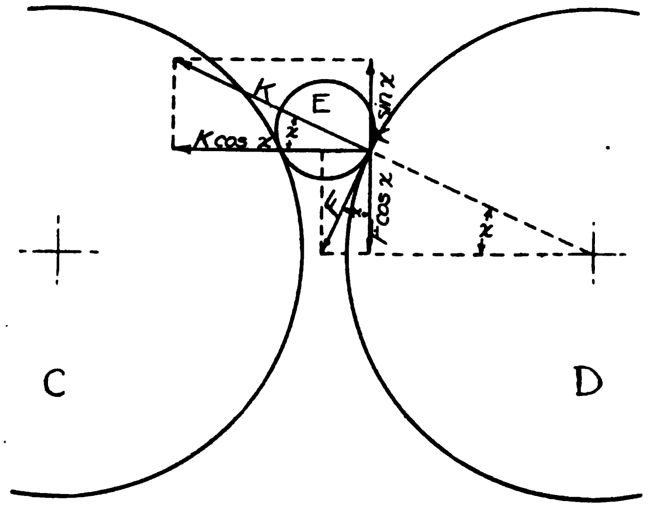


Figure 2. The Forces Acting Upon the Sphere of Rock to be Crushed and Their Components Are Shown By the Lines With Arrowheads.

The cosine (cos) of an angle is the ratio of the side adjacent to the angle to the hypotenuse. The tangent (tan) of an angle is the ratio of the side opposite the angle to the side adjacent to the angle, or it is equal to the ratio of the sine of the angle to the cosine of the angle, where the sine is equal to the side opposite the angle to the hypotenuse.

If the above forces were equal the following equation would hold true: $F \cos x = K \sin x$ or $F = K \tan x$. From this we conclude that for the rock to pass thru the rolls u must be greater than tan x, and hence, the angle x must be less than the angle of friction.

177—DECALCOMANIA, CHROMO OR LITHO-TRANSFER WORK

Lacquers for Transfers

1. Mastic, one ounce / Venetian turps., four ounces / White resin, two ounces / Sandrac, four ounces
   The above dissolved in twelve ounces of pure alcohol.
2. A solution of equal parts of colophony and copal varnish in oil of turpentine.
3. A solution of equal parts of soft pitch and Venetian turpentine in oil of turpentine.

From Searle.

183—DECORATIVE COLORING MATERIALS

Color effects are applied by incorporating the colors directly with the body, or by applying them on the surface of the body before glazing—by spraying or with brush, or by mixing the colors with the glaze or enamel, then spraying or dipping the articles.

The following colors are most commonly used in ceramics:

Iron. Red, brown, at moderate oxidizing atmosphere. Violet, bluish, greenish, and blackish in reducing atmosphere at high temperature.

Manganese. Brownish, violet, deep black mixed with cobalt or iron.

Cobalt. Blue, black, gray, mixed with zinc gives ultramarine blue, with manganese deep black, also purple.*

Chromium. Green, bright green with calcium or borax glaze, bluish green in glazes containing alkalies, yellow in reducing atmosphere. If applied on other bodies as white produces a muddy effect. The slightest quantity of iron darkens the color. The colors are very much affected by the influence of the atmospheric conditions inside the kiln at firing.

Uranium. Yellow in oxidizing atmosphere, orange yellow, green and black in reducing atmosphere; very bright yellow when mixed with plumbiferous glazes in oxidizing atmosphere.

Copper. Black, green, intense green in boric or plumbiferous glazes in reducing firing. Bluish green in alkaline glazes in oxidizing firing, the only blue is given by the cupric silicates, purple in reducing atmosphere, also red. Copper is usually used in glazes vitrified at a moderate temperature.

Antimony. Yellow, when mixed with lead or with iron, gives different tints. Alone imparts no color to the glazes and is used for opacifying.

Titanium. Yellow in different tints with varying amount of iron.

Lead. Yellow when lead chromate is used.

Nickel. Yellowish, greenish, also blue or purple.*

Silver Chloride. Yellowish. It is seldom used alone, except in addition to purple of Cassius.

Gold. Applied in different ways, as dull or brilliant gold.

Platinum. Silver, gray or black, it resists great heat as does gold.

Iridium. Gray to black.

Zinc. Imparts no color to glass and is used mostly as an opacifying agent the same as antimony.

It should be borne in mind that all the colors in bodies or glazes are confined within certain limits of temperature and are affected by atmospheric conditions inside of the kiln. Faulty fires may make the colors vary or possibly destroy them.

The properties of the different metallic oxides must be understood thoroly in order to know the temperatures at which they fuse or volatilize. The low fusing colors will run together with the refractory colors at high heat.

*Trans. A. C. S., Vol. 14, 1912.

Metallic combinations produce the following colors:

Oxide of chromium, green.
Oxide of iron, red, brown, violet, black, gray, yellow tints.
Oxide of uranium, orange, yellow, black.
Oxide of manganese, violet, brown, black.
Oxide of cobalt, blue, gray, black.
Oxide of antimony, yellow, different tints.
Oxide of titanium, yellow.
Oxide of copper, green suboxide of copper, red.
Sesquioxide of iridium, beautiful black.
Protochromate of iron, brown.
Chromate of lead (and chromate of barium), yellow.
Chloride of silver, as an addition to carmine and purple.
Purple of Cassius, purple.

Courtesy Malinovsky.

189—DEPRECIATION

Average Annual Figures in Percentages

Fixed plant:	
Buildings other than kilns	5 per cent
*Kilns, periodic	15 per cent
*Kilns, continuous	5-10 per cent
Engines and boilers	10 per cent
Clay working machinery	12 per cent
Pulleys, frames and shafting	5 per cent
Pumps and fittings for same	10 per cent
Piping that is accessible	5 per cent
Piping that is not accessible	12 per cent
Wire rope and chain for hauling	33 per cent
Surface railway	10 per cent
Movable plant:	
Wagons	15 per cent
Horses and mules	12 per cent
Carts and harness	12 per cent
Tools, wheelbarrows	15 per cent
Automobile trucks	25 per cent

*Estimated from observation by Brick and Clay Record.
From Searle.

203—DRAFT GAGE AND METER

Let T_1 = absolute temperature of outside gases.
T_2 = absolute temperature of inside gases.
H = height of chimney.
A = area of chimney.
w_1 = weight of one cu. ft. at temperature T_1
w_2 = weight of one cu. ft. at temperature T_2

Then $\frac{w_1}{w_2} = \frac{T_2}{T_1}$ and $w_1T_1 = w_2T_2$

Again $H\,A\,w_1$ = weight of gases outside of stack equal to quantity inside of stack.

$H\,A\,w_2$ = weight of gases inside of stack.

$H\,A\,(w_1 - w_2)$ = draft = F

$$H\,A\left\{w_1 - \frac{w_1\,T_1}{T_2}\right\} = F$$

$$H\,A\,w_1\left\{1 - \frac{T_1}{T_2}\right\} = F$$

At a temperature of 622 degrees F. maximum draft is obtained. This means that at that temperature the maximum quantity or weight of gases passes up a chimney. The maximum intensity is found only with the maximum temperature but after the temperature reaches that point the density of the gas decreases more rapidly than its velocity increases, so that the weight is maximum at about 622 degrees F. Draft varies with effective area. Long horizontal flues and right angled bends check draft.

The actual draft in inches of water $= h\left\{\frac{7.6}{a} - \frac{7.9}{b}\right\}$

when h = height of chimney in feet;
a = absolute temperature of external air (= degrees F. + 491)
b = absolute temperature of internal air (= degrees F. + 491)

If the internal gases are at a temperature of 600 degrees F. and the external air at 60 degrees F. the draft in inches equals h x .007.

The following table from Searle's Clayworkers' Handbook shows the height of the stack required to produce a given draft:

Height of stack in feet	Suction at base of stack in inches of water, with exit gases at 600 degrees F.
50	0.350
75	0.525
100	0.700
150	1.050
200	1.400
250	1.750
300	2.100

While a high draft must be used in the first stages of burning clay products, provision must be made for reducing this as the burn progresses and in the case of some ware that must be finished with a reducing fire, provision must be made for shutting off the draft almost completely. The reader is referred to page 178 under item Kiln, downdraft, design and construction of, for data showing that every ton of clay products produces approximately 8,100 cubic feet of moisture or steam that must be removed, chiefly thru a stack in the case of a down draft kiln.

The draft or speed with which the gases pass up a stack should not be less than five lineal feet per second.

204—DRAIN TILE

The following specifications are excerpts from the standard specifications adopted by the American Society for Testing Materials for drain tile.

These specifications cover three classes of drain tile, namely, Farm Drain Tile, Standard Drain Tile, and Extra-Quality Drain Tile.

The purposes for which these classes are intended to be suitable are as follows:

Farm Drain Tile, for ordinary private drainage work on farms, for moderate sizes and depths;

Standard Drain Tile, for ordinary district land drainage at moderate depths;

Extra-Quality Drain Tile, for district land drainage, for considerable depths and where an extra quality is desired.

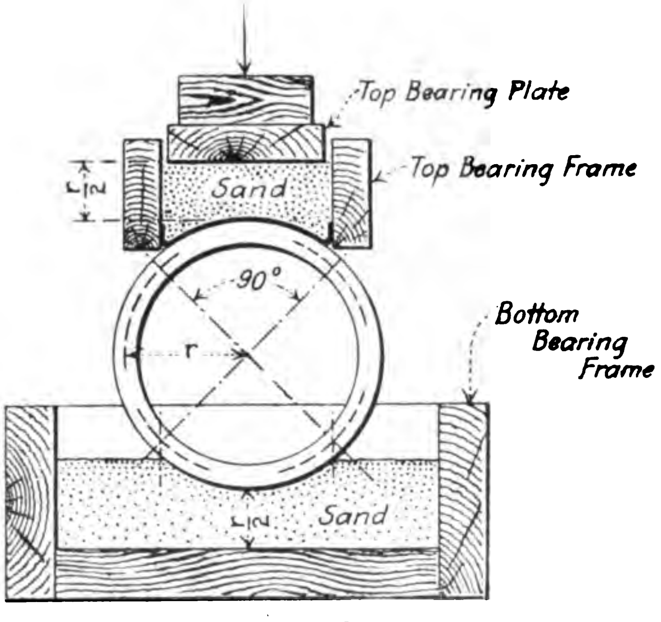


Fig. 1. Sand Bearings

The acceptability of drain tile shall be determined (1) by results of the chemical and physical tests hereinafter specified, and (2) by visual inspection, to determine whether the tiles comply with the specifications as to dimensions, shape, and freedom from visible external and internal defects.

Materials and Manufacture

These specifications shall apply to drain tile made of shale, fire clays or surface clays and to drain tile made of concrete. The definitions of shale, fire clay and surface clay can be found on page 125 under item Brick, sewer.

By concrete is meant a suitable mixture of Portland cement, mineral aggregates and water, hardened by hydraulic chemical reaction.

Chemical Tests and Requirements

The purchaser may specify special chemical requirements as to resistance of the tile to chemical action in cases where soils or drainage waters have marked acid or alkaline character, or are of abnormally high temperature, and may prescribe chemical tests of the tile to ascertain whether these special requirements are met.

The presence in drain tile of visible grains or masses of caustic lime, iron pyrites, or any other minerals which are known to cause slaking or disintegration of the tile, shall be construed as a valid ground for rejection, unless satisfactory proof be submitted that the tiles are permanent and durable, and that the objectionable minerals are not present in quantity or condition to work damage.

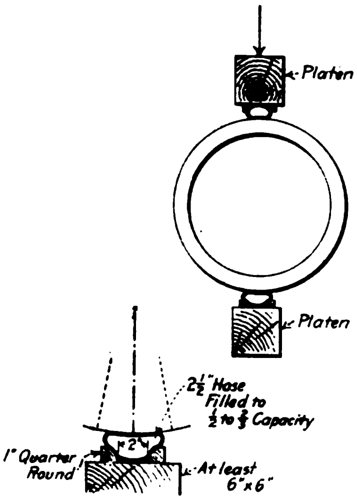


Fig. 2. Hydraulic Bearings

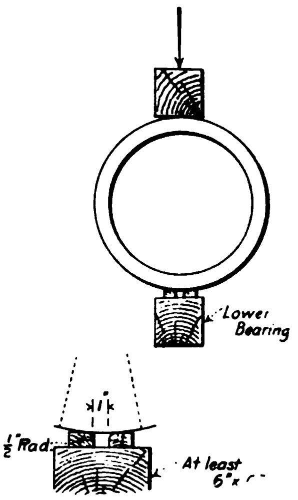


Fig. 3. Three Point Bearings

Physical Tests

The physical tests of drain tile shall include (A) Strength Tests; (B) Absorption Tests; and may include (C) Freezing and Thawing Tests.

Table I.—Physical Test Requirements for Different Classes of Drain Tile.

Internal Diameter of Tile In.	Farm Drain Tile				Standard Drain Tile				Extra-Quality Drain Tile			
	Minimum Average Ordinary Supporting Strength, Lb. per Linear Ft.	Max. Average Absorption by Standard Boiling Test, per cent.			Minimum Average Ordinary Supporting Strength, Lb. per Linear Ft.	Max. Average Absorption by Standard Boiling Test, per cent.			Minimum Average Ordinary Supporting Strength, Lb. per Linear Ft.	Max. Average Absorption by Standard Boiling Test, per cent.		
		Shale and Fire Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire Clay Tile	Surface-Clay Tile	Concrete Tile
4	800	11	14	12	1200	9	13	11	1600	7	11	10
6	800	11	14	12	1200	9	13	11	1600	7	11	10
8	800	11	14	12	1200	9	13	11	1600	7	11	10
10	800	11	14	12	1200	9	13	11	1600	7	11	10
12	800	11	14	12	1200	9	13	11	1600	7	11	10
14	900	11	14	12	1200	9	13	11	1600	7	11	10
16	1000	11	14	12	1300	9	13	11	1600	7	11	10
18	(Not Permitted)	(Not Permitted)	(Not Permitted)	(Not Permitted)	1400	9	13	11	1800	7	11	10
20					1500	9	13	11	2000	7	11	10
22					1600	9	13	11	2200	7	11	10
24					1700	9	13	11	2400	7	11	10
26					1800	9	13	11	2600	7	11	10
28					1900	9	13	11	2800	7	11	10
30					2000	9	13	11	3000	7	11	10
32					2100	9	13	11	3200	7	11	10
34					2200	9	13	11	3400	7	11	10
36					2300	9	13	11	3600	7	11	10
38					2400	9	13	11	3800	7	11	10
40					2500	9	13	11	4000	7	11	10
42					2600	9	13	11	4200	7	11	10

NOTE.—When the freezing and thawing test is made as detailed later, the number of freezings and thawings to be endured shall be as follows: For farm drain tile, 24; for standard drain tile, 36; for extra-quality drain tile, 48.

The specimens of tile shall all be selected at the factory or at the shipping destination, or at the trench, at the option of the purchaser. The selection shall be made by a competent inspector employed by the purchaser. The inspector shall divide the tile into sub-classes if lack of uniformity in any important particular warrants such division, and shall select enough representative specimens of tile from each sub-class for a complete set of standard physical tests.

A standard physical test shall comprise tests of five individual tiles. Specimens of tile may be selected by the inspector in such number as he judges necessary to determine fairly the quality of all the tile. The manufacturer or other seller shall furnish specimens of tile without separate charge up to 0.5 per cent. of the whole number of tile, and the purchaser shall pay for all in excess of that percentage at the same rate as for other tile.

Strength Tests of Drain Tile

The specimens of tile shall be unbroken, full-size tile.

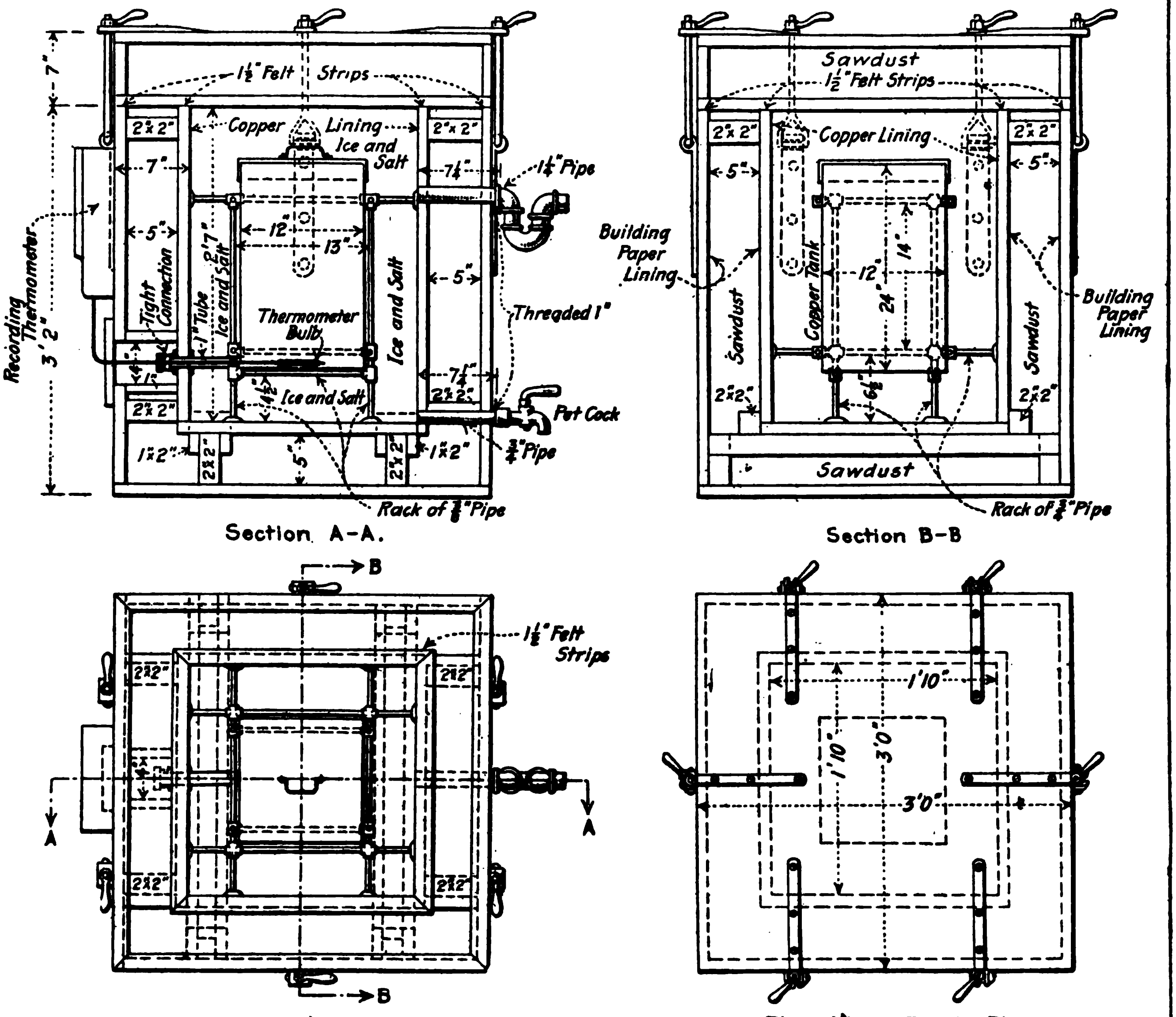
The walls of the tile shall, at the time of testing, be as thoroly wet as will result from completely covering with hay, cloth, or similar absorbent material, and keeping the covering wet for not less than 12 hours.

No specimen of tile shall be exposed to water or air temperatures lower than 40 deg. F. from the beginning of wetting until tested. Frozen tile shall be completely thawed before the wetting begins.

Each specimen of tile shall be weighed on reliable scales just prior to testing, and the weights shall be reported.

Any machine or hand method which will apply the load continuously, or in increments not exceeding 5 per cent. of the estimated total breaking load, may be used in making the test. The tile shall not be allowed to stand under load longer than is required for observing and recording the loads. All solid parts of the bearing frames and bearing blocks shall be so rigid that the distribution of the load will not be affected appreciably by the deformation of any part. All bearings and the specimens of tile shall be so accurately centered as to secure a symmetrical distribution of the loading on each side of the center of the tile in every direction.

The purchaser shall choose (1) sand bearings, (2) hydraulic bearings, or (3) three-point bearings, for use in making strength tests of drain tile. These are fully explained later.



Section A-A.

Section B-B

Plan View, Top Removed.

Plan View, Top in Place

Note: Box to be Constructed of Seasoned White Pine, free from Defects, or other Suitable Timber, 1"x 6", unless otherwise Specified.

SUGGESTED PLANS FOR FREEZING BOX USING SALT AND ICE TO FREEZE

The test results shall be calculated and reported, in pounds per linear foot of tile, in terms of the "Ordinary Supporting Strength."[1]

The ordinary supporting strength shall be calculated by multiplying the test breaking loads by the following factors: For sand bearings, 1.00; for hydraulic bearings, 1.25; for three-point bearings, 1.50.

The results of the strength tests shall be reported separately for each of the five individual specimens of tile constituting a standard test, together with the average.

The modulus of rupture may or may not be calculated and reported, at the option of the purchaser. When reported it shall be calculated by the equations[2]

$$M = 0.20r\frac{W}{12} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$f = \frac{6M}{t^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where M=maximum bending moment in wall in pound-inches per inch of length, r=radius of middle line of tile wall in inches, W=ordinary supporting strength, calculated as prescribed above, in pounds per linear foot of tile, f=modulus of rupture in pounds per square inch, and t=thickness of tile wall in inches.

Five-eighths of the weight of the tile per linear foot for sand bearings, or three-fourths for hydraulic or three-point bearings, shall be added to W in computing the maximum bending moment M, when such addition exceeds 5 per cent. of W. The value of t used shall be the average thickness of the wall at the top of the tile or that at the bottom, selecting the lesser of the two.

Sand Bearings

When sand bearings are used (see Fig. 1), the ends of each specimen of tile shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the tile measured on the middle line of the wall. The depth of bedding above and below the tile at the thinnest points shall be one-half the radius of the middle line of the wall.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the tile nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weight shall be piled symmetrically about a vertical line thru the center of the tile, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of the sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the tile during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the tile.

Hydraulic Bearings

When hydraulic bearings are used (see Fig. 2), the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

An hydraulic bearing shall be composed of a wooden platen, to which is attached, as hereinafter described, a section of rubber hose. The hose shall lie against the tile, and the pressure shall be applied to the hose thru the platen.

The platen shall be built of strong wood, and shall be not less than 6 by 6 in. in section, and its least length shall be the length of the tile plus 8 in. One-inch quarter rounds, with their convex surfaces facing and 2 in. apart in the clear, shall be firmly attached to the bearing side. The straight portion of this face shall extend at least the length of the tile, and the platen beyond this length may be cut to the arc of a circle.

Between the quarter rounds shall be laid a piece of 2½-in. hose which shall be closed in a water-tight manner at each end by clamps. The hose shall contain a volume of water not less than one-half nor more than two-thirds its capacity, when completely distended. This hose may be attached to the platen at either end in any satisfactory

---

[1] The "ordinary supporting strength" is approximately equal to the actual supporting strength of a tile when laid in a ditch by the "ordinary" method. See note under Table II.

[2] The coefficient of 0.20 in equation (1) approximates the value found by theoretical analysis and also that determined by extended tests.

Table II. Standard Ordinary Supporting Strengths of Drain Tile for Ordinary Sand and for Thoroly Wet Clay Ditch Filling Materials

Strengths in Pounds per Linear Foot

Height of Fill Above Top of Tile, Ft.	Breadth of Ditch at Top of Tile																			
	1 Ft.				2 Ft.				3 Ft.				4 Ft.				5 Ft.			
	Method of Laying Pipe				Method of Laying Pipe				Method of Laying Pipe				Method of Laying Pipe				Method of Laying Pipe			
	Ordinary		First Class		Ordinary		First Class		Ordinary		First Class		Ordinary		First Class		Ordinary		First Class	
	Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material		Ditch Filling Material	
	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay	Sand	Clay
2	265	280	220	235	615	635	510	530	970	990	810	830	1 330	1 350	1 110	1 130	1 690	1 710	1 410	1 430
4	400	450	335	375	1 050	1 120	880	935	1 750	1 820	1 460	1 520	2 450	2 540	2 040	2 110	3 160	3 250	2 640	2 710
6	470	545	390	455	1 370	1 500	1 140	1 250	2 370	2 530	1 980	2 110	3 410	3 580	2 840	2 980	4 460	4 640	3 720	3 870
8	505	605	420	505	1 600	1 790	1 330	1 490	2 870	3 110	2 390	2 590	4 220	4 490	3 510	3 740	5 590	5 890	4 660	4 910
10	525	640	440	535	1 760	2 010	1 470	1 680	3 270	3 610	2 730	3 010	4 900	5 290	4 080	4 410	6 590	7 020	5 490	5 850
12	535	660	445	550	1 880	2 190	1 570	1 820	3 600	4 030	3 000	3 355	5 480	6 000	4 570	5 000	7 460	8 030	6 220	6 690
14	540	675	450	560	1 960	2 320	1 640	1 930	3 850	4 380	3 210	3 650	5 980	6 620	4 980	5 520	8 230	8 950	6 850	7 460
16	545	680	455	565	2 030	2 420	1 690	2 020	4 060	4 670	3 390	3 890	6 400	7 160	5 330	5 970	8 890	9 770	7 410	8 150
18	545	685	455	570	2 070	2 500	1 720	2 090	4 230	4 920	3 530	4 100	6 750	7 630	5 630	6 360	9 480	10 520	7 900	8 770
20	545	690	455	575	2 100	2 560	1 750	2 140	4 370	5 130	3 640	4 280	7 050	8 060	5 880	6 720	9 990	11 200	8 330	9 330
22	545	690	455	575	2 120	2 610	1 770	2 180	4 470	5 310	3 730	4 420	7 310	8 430	6 090	7 020	10 400	11 800	8 700	9 830
24	545	690	455	575	2 140	2 650	1 780	2 210	4 560	5 450	3 800	4 540	7 520	8 750	6 270	7 290	10 800	12 300	9 030	10 300
26	545	690	455	575	2 150	2 670	1 790	2 230	4 630	5 580	3 850	4 640	7 700	9 030	6 420	7 530	11 200	12 800	9 320	10 700
28	545	690	455	575	2 160	2 700	1 800	2 250	4 680	5 680	3 900	4 740	7 860	9 280	6 550	7 740	11 500	13 300	9 570	11 100
30	545	690	455	575	2 170	2 710	1 810	2 260	4 730	5 770	3 940	4 810	7 990	9 500	6 660	7 920	11 800	13 700	9 800	11 400
Very Great	545	690	455	575	2 180	2 770	1 820	2 310	4 910	6 230	4 090	5 190	8 730	11 100	7 270	9 230	13 600	17 300	11 400	14 400

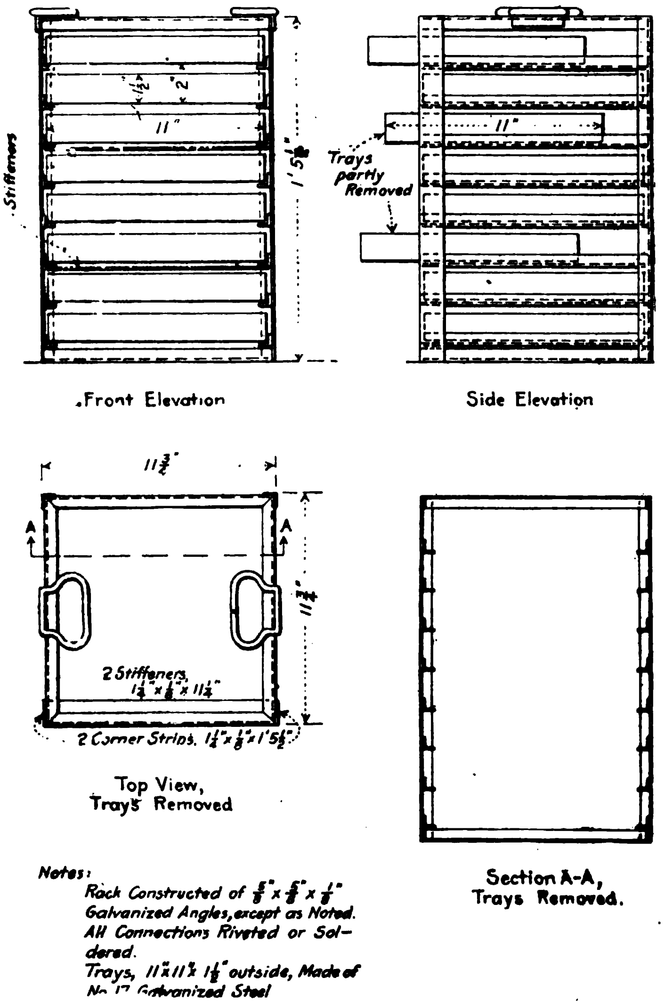
Note.—Ordinary Pipe Laying is pipe laying in accordance with customary good practice in tile-drain construction, whereby the underside of the pipe is well bedded on soil for 60 to 90 deg. of the circumference.

First-Class Pipe Laying is pipe laying in accordance with the best customary practice in pipe-sewer construction, whereby the entire underside of the pipe is very thoroly bedded on soil and the entire pipe is surrounded by well-compacted soil, under the direction of an inspector constantly present on the work.

When pipe is laid in a Concrete or Other Permanent Masonry Cradle, strong enough to carry the entire load to the subbase without breaking and large enough to prevent material settlement, the standard strengths for all dimensions of ditches and all filling materials shall be those specified for Standard Drain Tile in Table I.

manner which will not induce wrinkling when under test pressure.

The test load shall be applied at the middle of the top bearing, in such a way as to leave the bearing free to move in the vertical plane of the axis of the tile.



Front Elevation

Side Elevation

Top View,
Trays Removed

Section A-A,
Trays Removed.

Notes:
Rack Constructed of ⅝" x ⅝" x ⅛" Galvanized Angles, except as Noted.
All Connections Riveted or Soldered.
Trays, 11"x11"x 1⅛" outside, Made of No. 17 Galvanized Steel

Fig. 4.—Suggested Plans for Freezing Crate and Trays

It is recommended that stops be screwed to the platen, symmetrical with the point of application of the load, and at a distance apart not greater than the length of the tile plus ½ in. This will help center the load coming upon the tile.

Three-point Bearings

When three-point bearings are used (see Fig. 3), the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

The lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately ½ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied thru the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a tile which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

For the absorption tests the reader is referred to the entry under Absorption in the definition section, as the two methods are almost identical.

Freezing and Thawing Tests of Drain Tile

The specimens shall be immersed for 72 hours in water having a temperature of 18 to 24 deg. C. (65 to 75 deg. F.) and then weighed. For freezing, they shall be placed with their concave faces upward in watertight metal trays, suitably mounted in a rigid metal crate,[1] and immersed in ice water until the specimens have attained substantially the temperature of the water, after which the water shall be drawn down to a depth of ½ in. in each tray. The crate shall then be lifted as a whole, without disturbing the specimens, and placed in the freezing apparatus.

Freezing shall be performed in a quiet atmosphere, free from perceptible natural or artificial currents. If artificial freezing apparatus is employed,[2] the apparatus shall have sufficient heat-absorbent capacity to enable the temperature of the freezing chamber to be brought to — 10 deg. C. (+14 deg. F.) or below, within thirty minutes after the introduction of the specimens. The temperature in the freezing apparatus shall not fall lower than — 20 deg. C. (— 4 deg. F.). The freezing shall be continued until the water in the trays is frozen solid. Exposure to freezing conditions in excess of this requirement shall be considered as without significance.

At the conclusion of freezing under the specified conditions, the crate of specimens shall be withdrawn and at once immersed in water at a temperature of 18 to 24 deg. C. (65 to 75 deg. F.) in a special receptacle of proper size. Heating shall be continued so that the water will regain the required temperature as soon as practicable after the specimens are immersed. A temperature of 18 to 24 deg. C. (65 to 75 deg. F.) shall then be maintained for not less than 2 hours. At the conclusion of the thawing treatment, the crate of specimens shall be inspected and the condition of each sample after each thawing shall be noted in the records.

Failure under the freezing and thawing treatment shall be considered to be reached when:

(a) The specimens show superficial disintegration or spalling with loss of weight of more than 5 per cent. of the initial dry weight; or,

(b) The specimens are badly cracked in other than lamination planes; or,

(c) The specimens show evident serious loss of structural strength.

Physical Test Requirements

The physical test requirements for the different classes of drain tile shall be as given in Table I.

Drain tile made of mixtures of surface clays with other clays shall conform to the absorption requirements for surface-clay tile in Table I, when the proportion of surface clay is 75 per cent. or more, and to the requirements for shale and fire-clay tile for all other proportions.

In the event that a standard sample of tile fails to meet the requirements of the absorption test, the manufacturer or other seller may demand recourse to the freezing and thawing test, to be made at his expense. In such recourse, the number of tiles tested shall be 20. If the material passes the freezing and thawing test satisfactorily, it shall not be rejected on account of its failure to meet the absorption requirements specified in Table I, but the average percentage of absorption of the specimens used in the freezing and thawing test shall be

Table III. Distinctive General Physical Properties of Different Classes of Drain Tile

Physical Properties Specified	Farm Drain Tile	Standard Drain Tile	Extra-Quality Drain Tile
Allowable variation of average diameter below specified diameter, per cent	5	3	3
Allowable variation between maximum and minimum diameters of same tile, or average diameters of adjoining tile, percentage of thickness of wall	85	75	65
Allowable variation from straightness, percentage of length	5	3	3
Allowable thickness of exterior blisters, lumps and flakes which do not weaken tile and are few in number, percentage of thickness of wall	25	20	15
Allowable diameters of above blisters, lumps and flakes, percentage of internal diameter	20	15	10
General Inspection	Careful	Rigid	Very rigid

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[1] Fig. 4 shows a crate and trays suitable for use in the box for artificial freezing illustrated on page 159.

[2] Artificial freezing will generally be necessary. It may be conducted in a commercial zero (F.) refrigerating room or in an artificial freezing box similar to the one shown on page 159, in which zero (F.) temperatures can readily be produced by the use of salt and ice.

adopted as the maximum allowable mean absorption for the contract in question.

In the strength tests, individual tiles of a standard test whose mean strength is satisfactory may fall 25 per cent. below the requirement for the average without causing rejection. In the absorption test, the absorption of individual tiles of a standard sample, which gives a satisfactory mean absorption percentage, may exceed the average by 25 per cent. without causing rejection. In the freezing and thawing test, at least 95 per cent. of all the tiles tested shall meet the requirement.

In the event of the failure of a standard sample to meet the above requirements, the manufacturer or other seller may thoroly cull the material and submit a portion for retest at his own expense, and for such retest the number of tiles per sample shall be 10 for the strength and absorption tests and 20 for the freezing and thawing test. In the event of the failure of the material after culling to pass the requirements, it shall be rejected without further test.

Visual Inspection

The sizes of drain tile shall be designated by their interior diameters.

Drain tile smaller than 12 in. in diameter shall have a minimum length of 12 in. Tile of from 12 to 30 in. in diameter, inclusive, shall have lengths not less than the diameters. Tile larger than 30 in. in diameter shall have a minimum length of 30 in.

Drain tile shall be substantially uniform in structure thruout, and an inspector shall investigate this property by examining fractured surfaces.

Drain tile shall give a clear ring when stood on end and while dry tapped with a light hammer.

Drain tile shall be reasonably smooth on the inside.

Drain tile shall be free from cracks and checks extending into the body of the tile in such a manner as to decrease the strength appreciably. Tile shall not be chipped or broken in such a manner as to decrease their strength materially or to admit earth into the drain.

All drain tile shall be sufficiently "vitrified" or "hard-burned" to afford the degree of supporting strength, percentage of absorption, and resistance to freezing and thawing specified in the physical test requirements prescribed in Table I.

Drain tile of the different classes shall, in addition to all requirements heretofore specified, have the distinctive physical characteristic prescribed in Table III.

213—DRIVE, SILENT CHAIN

Notes on Design

Designing drives within the following limitations represents best practice:

PITCH OF CHAIN (Nominal)	3/8	1/2	5/8	3/4	1	1¼	1½	2	2½
Minimum number of teeth in driving wheel	15	17	17	17	17	17	17	19	19
Minimum number of teeth in driven wheel	17	19	19	19	21	21	21	23	23
Maximum revolutions of minimum wheel	2260	1835	1460	1220	920	800	700	530	425
Corresponding chain speed	1200	1300	1300	1300	1300	1400	1500	1500	1500

Encased Drives with constant lubrication can be designed to operate at chain speeds up to 2,500 feet per minute.

Minimum center distance = Diameter of larger wheel + half the diameter of smaller wheel.

It is not economical to exceed any of these limitations for the sake of obtaining a lower first cost. If, however, the conditions necessitate exceeding these figures, submit the full particulars to a manufacturer.

Desirable Features	An odd number of teeth in pinions. An even number of links (or pitches) in the chain. Adjustability in the distance between centers of wheels, to regulate or eliminate the slack, as occasion may require.

Different pitches and widths of chains may have about the same horsepower rating, as for instance, ½" pitch 2" wide, 5/8" pitch 1½" wide, and ¾" pitch 1¼" wide. From a mechanical standpoint, the chains whose widths range from 2 times the pitch to 6 times the pitch, are preferable and are generally employed. The longer-pitch narrower chains are cheaper than shorter-pitch wider chains, but are likely to require somewhat larger wheels. They are preferable in drives having a long proportionate distance between centers.

The horsepowers listed for the chains are based on a uniform rate of work, where there is little shock or variation in the load thruout a single revolution of the driven wheel.

Drives running such machinery as single acting pumps, compressors, etc., or operating more than ten hours per day, should be figured at ten to fifty per cent. above rated power, depending upon the judgment of the engineer as to the maximum momentary strains that may be developed, the frequency of such strains, the portion of the time the drive is under maximum load, and the percentage of the total time the drive is in operation.

The selection of heavier chains than the minimum sizes recommended, will give more than a corresponding return in the service rendered. This is particularly true in small drives, where the overloads are proportionately high.

The approximate ultimate strengths of the chains can be obtained by multiplying the pitch in inches by the width in inches, and multiplying this by 5,500. This would make, for instance, a 2-inch pitch chain 12 inches wide have an ultimate strength of 132,000 lbs. (2×12×5,500=132,000.)

Durability, and not ultimate strength, is the important element in selecting proper chains.

Courtesy Link-Belt Co.

212—DRIVE, ROPE

The table below shows the proper relation between the rope and sheaves used in transmitting power by means of wire rope, and approximately the amount of power that may be thus transmitted. The calculations are based upon a rope of the 6 strand, 7 wires per strand construction:

Diameter of Sheave in Feet	Number of Revolutions per Minute	Diameter of Rope	Horse-power	Diameter of Sheave in Feet	Number of Revolutions per Minute	Diameter of Rope	Horse-power
3	80	3/8	3	7	140	9/16	35
3	100	3/8	3½	8	80	5/8	26
3	120	3/8	4	8	100	5/8	32
3	140	3/8	4½	8	120	5/8	39
4	80	3/8	4	8	140	5/8 9/16	45 47
4	100	3/8	5	9	80	5/8 9/16	48 58
4	120	3/8	6	9	100	5/8 9/16	60 69
4	140	3/8	7	9	120	5/8 9/16	73 82
5	80	7/16	9	9	140	5/8	84
5	100	7/16	11	10	80	5/8 11/16	64 68
5	120	7/16	13	10	100	5/8 11/16	80 85
5	140	7/16	15	10	120	5/8 11/16	96 102
6	80	1/2	14	10	140	5/8 11/16	112 119
6	100	1/2	17	12	80	11/16 3/4	93 99
6	120	1/2	20	12	100	11/16 3/4	116 124
6	140	1/2	23	12	120	11/16 3/4	140 149
7	80	9/16	20	12	120	7/8 1	173 141
7	100	9/16	25	14	80	1⅛ 1	148 176
7	120	9/16	30	14	100	1⅛	185

146—CONDENSER

Condensing engines require from 20 to 30 gallons of water to condense the steam represented by every gallon of water evaporated—approximately for most engines, we say, from one to one and a half gallons per minute per horse power. Jet condensers do not require quite as much water for condensing as surface condensers.

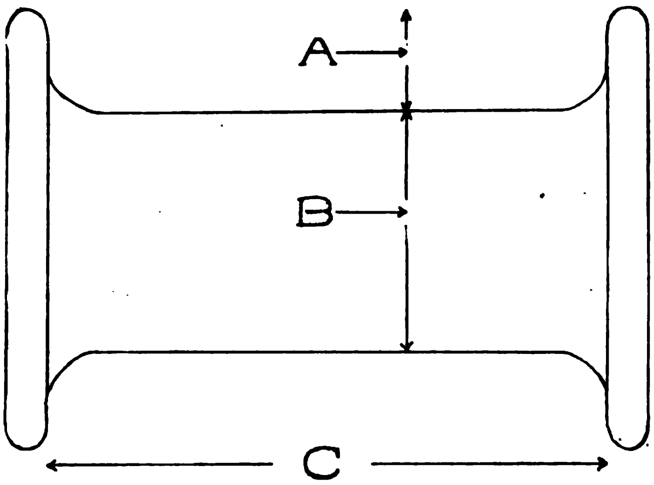
214—DRUM, WINDING

A Formula for Computing the Capacity of Any Drum for Rope

Dimensions are all in inches. Add the depth of flange (A) to the diameter of the drum (B). Multiply this sum by the depth of the flange (A). Multiply the result by the width of the drum between flanges (C). Multiply this result by the figure in column opposite the size of rope.

This in the form of a formula is

Capacity of the drum in feet$=(A+B)\times A\times C\times$multiplier.



Sketch for Computing Capacity of Drum

Multipliers

¼ inch	4.16
⅜ inch	1.86
7/16 inch	1.37
½ inch	1.05
9/16 inch	.828
⅝ inch	.672
¾ inch	.465
⅞ inch	.342
1 inch	.262
1⅛ inch	.207
1¼ inch	.167
1⅜ inch	.138
1½ inch	.116
1⅝ inch	.099
1¾ inch	.085
1⅞ inch	.074
2 inch	.066
2⅛ inch	.058
2¼ inch	.052
2⅜ inch	.046
2½ inch	.042

228—DRYER, STEAM

Equalization of Pipes

One square foot of radiating surface equals

3.63 lineal feet of ¾ inch pipe
2.9 lineal feet of 1 inch pipe
2.3 lineal feet of 1¼ inch pipe
2.01 lineal feet of 1½ inch pipe
1.608 lineal feet of 2 inch pipe
1.329 lineal feet of 2½ inch pipe
1.090 lineal feet of 3 inch pipe
0.955 lineal feet of 3½ inch pipe
0.848 lineal feet of 4 inch pipe
0.763 lineal feet of 4½ inch pipe
0.685 lineal feet of 5 inch pipe
0.576 lineal feet of 6 inch pipe

In connection with steam coils for a reduced pressure of 30 pounds the following sizes should be used:

Sq ft. of surface	Size of steam main	Size of return
450	2 inches	1¼ inches
650	2½ inches	1½ inches
1,000	3 inches	2 inches
1,350	3½ inches	2 inches
1,725	4 inches	2½ inches
2,700	5 inches	3 inches
4,000	6 inches	3½ inches

How Much Radiation Will an Exhaust Supply?

A simple engine requires 35 lbs. of steam per H. P. per hour on an average. This steam will contain, say, 980 heat units as it is exhausted, and the engine will therefore deliver about 34,300 heat units per H. P. per hour in its exhaust. About 3,430,000 heat units are thus available from a 100 H. P. engine per hour. If this were all used in a heating system and the returns came back at 150 deg. there would be available roughly 3,000,000 B. t. u. Allowing a radiation of 250 B. t. u. per sq. ft. from the ordinary radiator, the exhaust from a 100 H. P. engine would therefore supply roughly 12,000 square feet of radiation, provided no steam were used for heating the feed water.

The radiation per hour per square foot of radiating surface is considered to be 280 B. t. u.

223—DRYER, RELATION OF AIR TO

Searle's Clayworkers' Handbook has the following table which assists in determining the amount of air required to drive one pound of water from clay ware.

Temperature of Air Entering Dryer Degree F.	Temperature Leaving Dryer Degree F.	Weight of Air Required Pounds	B.T.U. required to Drive 1 Pound of Water Out of Clay
72	52	227	2156
98	62	125	1954
130	72	77	1788
170	82	50	1652
220	92	34	1537

This table is figured for full saturation, but since this condition is practically never attained proper allowance must be made for the proper conditions.

Searle also gives the following showing the weights and volumes of air at various temperatures which will contain, when saturated, one pound of water in the form of vapor:

Degrees F.	Weight of Air Pounds	Volume of Mixture Cubic Feet
42	178.18	2272
52	122.17	1595
62	84.79	1135
72	59.54	819
82	42.35	600
102	21.98	333
132	8.49	151
182	1.402	48.7

235—DYNAMITE

Steel Storage Magazines

No.	Capacity	Size	Weight
1..	108 kegs, 54 dynamite cases	3'x6'x 6'	800 lbs.
2..	216 kegs, 108 dynamite cases	6'x6'x 6'	1,250 lbs.
3..	324 kegs, 162 dynamite cases	6'x6'x 9'	1,500 lbs.
4..	504 kegs, 252 dynamite cases	8'x7'x 9'	2,000 lbs.
5..	672 kegs, 336 dynamite cases	8'x7'x12'	2,400 lbs.
6..	840 kegs, 420 dynamite cases	8'x7'x15'	2,800 lbs.
7..	1,056 kegs, 528 dynamite cases	11'x8'x12'	3,200 lbs.
8..	1,320 kegs, 660 dynamite cases	11'x8'x15'	3,700 lbs.
9..	1,584 kegs, 792 dynamite cases	11'x8'x18'	4,200 lbs.
10..	1,848 kegs, 924 dynamite cases	11'x8'x21'	4,700 lbs.

Portable Iron Magazines—on Wheels

No.	Capacity	Size	Weight
1..	8 kegs, 4 dynamite cases	24"x24"x25"	145 lbs.
2..	12 kegs, 6 dynamite cases	21"x25"x31"	165 lbs.
3..	16 kegs, 8 dynamite cases	21"x25"x40"	195 lbs.
4..	24 kegs, 12 dynamite cases	26"x28"x48"	340 lbs.
5..	30 kegs, 15 dynamite cases	30"x30"x50"	390 lbs.

Courtesy Hercules Powder Co.

141—COAL, HEAT VALUE OF

Approximate heating value judging from the moisture and ash content.

At times the heating value of a coal is expressed in b. t. u. as the moisture and ash free calorific value. If a customer has this figure and has been able to determine the ash and moisture content he can easily figure the heating value of the coal as received by adding the ash and moisture contents together and deducting this total percentage from the heating value as shown, ash and moisture free.

240—ELECTRICAL PORCELAIN

The following specifications are excerpts from the tentative specifications suggested by the American Society for Testing Materials.

These tests are intended to apply to porcelain which is to be used for electrical insulating purposes.

Tensile Strength

Any standard testing machine may be employed, but it shall be of suitable capacity.

Test specimens may be prepared by pugging or extruding rolls of suitable size, throwing rolls by hand or by cutting rolls from pugged blocks. For comparative tests one method of preparing specimens should be adhered to as test specimens prepared by different processes show different results. They shall be turned in the green condition to such dimensions as will give fired pieces of standard size, shrinkage being determined and allowed for as in regular ceramic practice. Variation from the standard dimension shall be kept within + or — 5 per cent., as it has been found that the strength per square inch calculated from results obtained with test specimens of about 0.2 sq. in. increases about 0.5 per cent. for a decrease in area of 1 per cent.

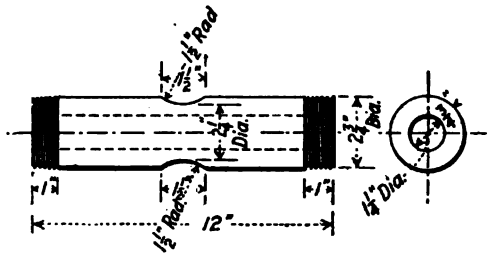


Fig. 1.

Test specimens shall be fired in saggers on end, either on placing sand or clay bats. They shall not be buried in sand as this will cause the pieces to break in firing. Firing shall be carried out in the regular porcelain kilns. Specimens which have warped in firing shall be rejected because they will give unreliable results and therefore a sufficient number of specimens should be prepared to give the required number of satisfactory ones.

Ohio Brass Co. Method

The test specimens shall have the shape and dimensions shown in Fig. 1.

Jeffry-Dewitt Insulator Co. Method

The test specimens shall have the shape and dimensions shown in either Fig. 2 or Fig. 3. The maximum cross-section area in the reduced section of the specimen shall not be greater than 0.2 sq. in.

When dry, the shoulder of the specimens shall be glazed, leaving the reduced section free from glaze.

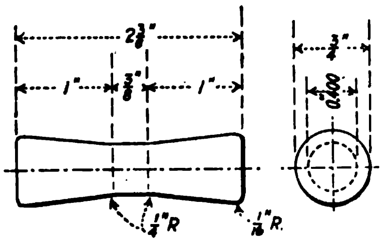


Fig. 2.

Note.—The glaze is necessary to obtain uniform results and insure that failure occurs in testing in the reduced section. The glaze is omitted from the reduced section in order to avoid variation in strength which may be attributable to the glaze.

O. B. Method

The method of mounting the test specimen in the specimen holders is shown in Fig. 4. The method of using the assembly jig shown in the figure is as follows: The test specimen is calipered at the small section. The tapered jig, G, with the arbor, E, is then placed in the guides, V. The point on the tapered piece, G, which has the same diameter as the minimum section on the specimen is placed directly over the V-notched block, N. This piece is then raised until it comes in contact with the piece, G, and the wing nut, S, tightened. E and G are then removed and the cap pieces, C, screwed on to the rods, R, which are laid in the notches V-V. The center of the specimen is placed in the V-notched block, N, and the clamping piece, L, tightened down to hold it in place.

One of the caps, C, with the attached rod, R, can then be moved over the end of the specimen and held in place by tightening the strap, H; the whole assembly apparatus is then stood on one end and the cap moved so as to allow filling with cement. The cap is then moved up in place, rotating it at the same time so as to properly work in the cement. The strap, H, is then tightened and the piece left undisturbed until the cement hardens.

When the cap has been attached at one end, the assembly apparatus can be stood on the other end and the other cap cemented in place.

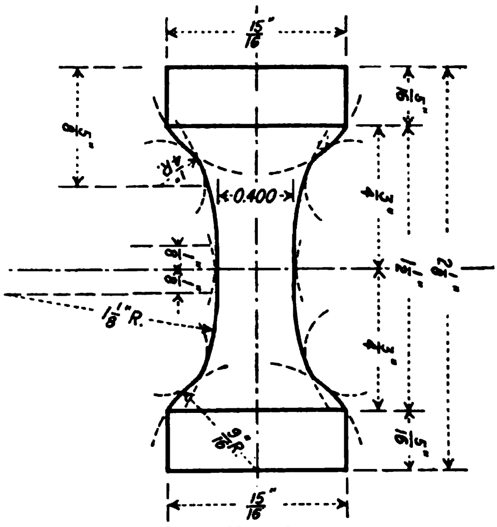


Fig. 3.

Note.—This arrangement permits of setting up the jug properly and easily for specimens which vary slightly in diameter and insures keeping the center line of the specimen in the center line of the caps. A slight tip of the specimen will be unimportant so long as both caps can be assembled to the specimen.

After the cement has hardened (which will not require more than five or ten minutes if litharge cement is used), the specimen, can be removed and eyes screwed into caps in place of the rods, R.

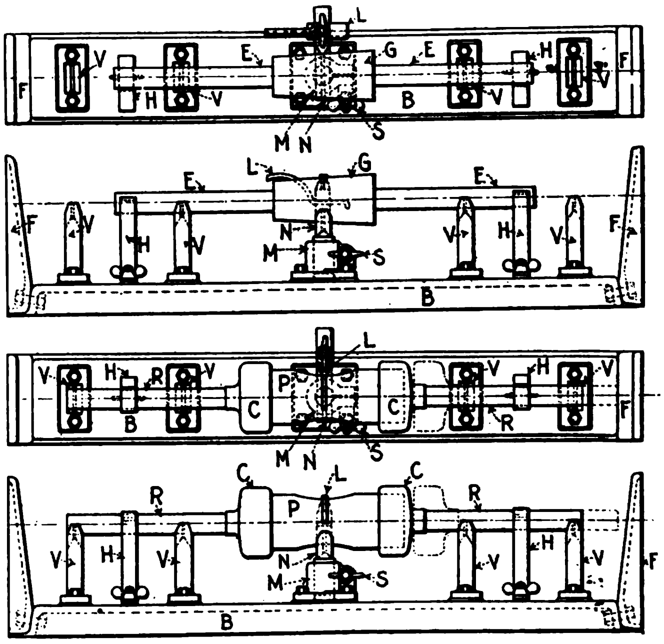


Fig. 4.

J-D Method

The method of mounting the test specimen in this method of testing is as follows:

Test Specimen, Fig. 2 (Conical Ends)

The specimen shall be held by small steel clamps, Fig. 5, each consisting of a split bushing, B, ground to fit the test specimen, T, and held by a collar, C, the load being applied by the plate, P, held in slots of the jaws of the testing machine thru the ball and socket joint, J. The soft gasket, G, of blotting paper shall be inserted between the porcelain and the bushing to distribute the load. A new gasket shall be used with each specimen.

Test Specimen, Fig. 3 (Dumb-bell Ends)

The specimen is held by a split ring, R, Fig. 6, with the same radius of curvature as the shoulders of the specimen. This ring fits into a recess in plate P_3 which, in turn, fits into the slots in the jaws of the testing machine.

Note.—No gasket is required with this piece when the shoulders are glazed. Satisfactory results have not been obtained with unglazed pieces, even when using a gasket. This form of specimen has the advantage of requiring no gasket and so is more rapid in manipulation and of allowing greater variation in dimensions.

Not less than 10 specimens (preferably more) shall be tested in the normal condition.

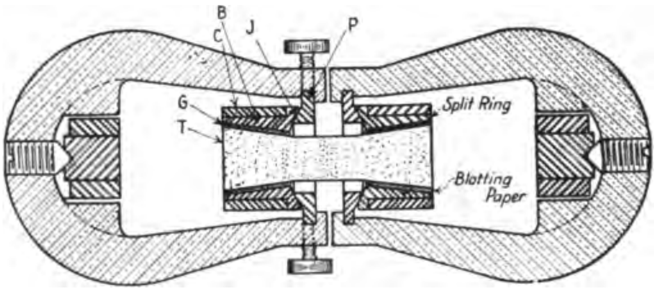


Fig. 5.

The specimen shall be pulled apart at such a constant speed that the beam of the testing machine can be kept well balanced at all loads.

When failure occurs outside of the reduced section, that result shall be discarded.

The tests shall be made at a room temperature of about 20 deg. C. (68 deg. F.).

The report shall include the following:

The diameter in inches or centimeters as measured by a micrometer at the point of fracture.

The breaking load of each specimen in pounds or in kilograms.

The ultimate strength in pounds per square inch or in kilograms per square centimeter of each specimen as calculated from the actual area of the specimen measured at the point of fracture.

The average of these results:

The character of the material tested and a description of its behavior under stress.

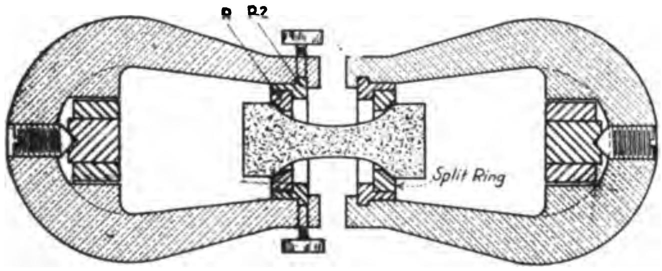


Fig. 6.

The speed in inches or centimeters per minute at which the jaws traveled during the test.

Compressive Strength

Any standard testing machine may be used. A contact pad or cushion of $\frac{1}{32}$ in. of blotting paper shall be placed between the upper and lower faces of the specimens and the heads of the testing machine to equalize irregularities in the surfaces. Fresh cushions shall be used for each specimen tested.

The test specimen shown in Fig. 7 shall be used for the compressive strength test.

Not less than 10 specimens (preferably more) shall be tested in the condition in which they are received.

The load shall be applied at that constant rate of speed which will permit the beam to be kept well balanced at all loads.

The test shall be made at a room temperature of about 20 deg. C. (68 deg. F.).

The report shall include the following:

The dimensions of each specimen in inches or in millimeters.

The load in pounds or kilograms on each specimen at the first sign of fracture.

The ultimate compressive strength in pounds per square inch or in kilograms per square centimeter for each specimen calculated from the measured area before the load is applied.

The average of these results:

General character of the material tested and a description of its behavior under load.

The speed in inches or in centimeters at which the jaws traveled during the test.

Resistance to Impact

The test shall be made with the apparatus shown in Fig. 8.

The test specimen shown in Fig. 7 shall be used for impact tests.

The specimen shall be placed on the base of the device directly under the hammer with a disc of blotting paper on the top of the specimen. The collars shall be set for a 6-in. drop of the hammer. The hammer shall be raised to the stops and allowed to fall unimpeded upon the specimen. A fresh disc of blotting paper shall be used for each blow of the hammer.

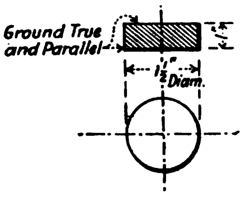


Fig. 7.

The entire hammer shall weigh 1.87 lb. (850 g.).

If the specimen remains unbroken after 20 blows of the hammer using the 6-in. drop, the drop shall be increased to 7 in. and the test repeated. If the specimen remains unbroken after 20 blows using the 7-in drop, the distance shall be increased to 8 in. and the test repeated. If necessary, increasing the height 1 in. per 20 blows shall be continued until the specimen breaks.

Not less than five specimens shall be tested in the condition in which they are received.

The report shall include a statement of the number of blows required to break each specimen with a 6-in. fall of the hammer or, if failure did not occur with the 6-in. drop, the total number of blows and heights of drop necessary to fracture each specimen.

Dielectric Strength

The apparatus shall be as described in Section 14 of the Tentative Methods of Testing Molded Insulating Materials (Serial Designation: D 48—21 T) of the American Society for Testing Materials.[1]

The specimens shall be as shown in Fig. 1 except that the threads may be omitted.

Porcelain for All Purposes

A pad of wet clay about ¼ in. thick shall be laid in the groove and a lining of wet clay about ¼ in. thick put on the inside of the specimen. The potential shall be applied to these two pads of clay by any suitable means. Mercury may be substituted for the wet clay if desired. The test should preferably be made in air but it may be made in transformer oil if necessary.

Not less than ten specimens shall be punctured in their normal condition at a normal room temperature of about 20 deg. C. (68 deg. F.).

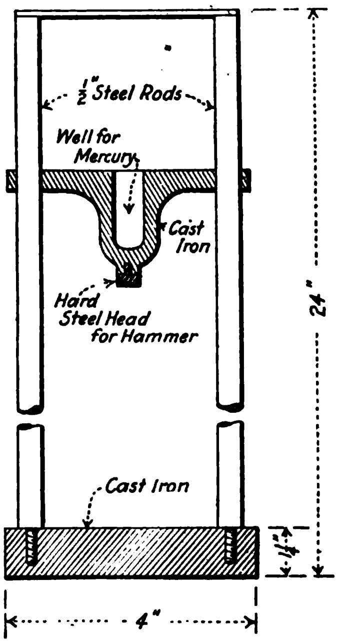


Fig. 8.

Porcelain for Transmission Line Insulators

In addition to the first test prescribed, not less than 10 specimens shall be tested in the same manner at a temperature of 75 deg. C. (167 deg. F.).

Porcelain for Spark Plugs

In addition to the first test prescribed, not less than 10 specimens shall be tested to determine the effect of high temperatures on the dielectric strength. The specimens shall be placed in an electrically heated oven the temperature of which can be raised at a constant rate to 600 deg. C. (1,112 deg. F.). A given voltage shall be applied and maintained constant and the temperature raised at any constant rate such that the porcelain is always practically at the temperature of the air. The temperature shall be raised until puncture occurs.

Whenever a puncture occurs at a point other than the minimum section of the specimen in any of the tests prescribed above, that result shall be discarded.

The report shall include the following:

A statement of the purpose for which the porcelain is intended and the kind of tests which were made.

The thickness of the specimen at the bottom of the groove.

The voltage at puncture for each of the test specimens together with the average, maximum and minimum volts per mil or per millimeter of thickness.

Resistance to Thermal Change

Porcelain for Transmission Line Insulators

The apparatus shall consist of a hot water bath maintained at a temperature of 100 deg. C. (212 deg. F.) and an ice water bath maintained at 0 deg. C. (32 deg. F.).

The test specimens shall be as shown in Fig. 1.

The test specimen shall be immersed in the ice water bath for ten minutes and then transferred as quickly as possible to the hot water bath, and allowed to remain there for ten minutes. The specimen shall be transferred back to the cold water and the cycles continued until the specimen breaks.

Not less than five specimens shall be tested.

Report the number of cycles necessary to cause fracture of each test specimen.

Porcelain for Spark Plugs and Heating Devices

A furnace in which a temperature of 900 deg. C. (1,652 deg. F.) can be obtained and any suitable testing machine for determining the transverse strength of small beams may be used.

The specimens shall be as shown in Fig. 3.

One-half of not less than 12 specimens shall be taken and placed in the furnace. The rate of heating shall be so adjusted that the temperature reaches 900 deg. C. (1,652 deg. F.) in two hours. The furnace shall then be allowed to cool at such a rate that room temperature is reached in four hours.

All specimens for transverse strength shall be tested by placing them on supports 6 in. apart and loading them at the center.

The report shall include the following:

The load in pounds or kilograms required to break each specimen not subjected to heat treatment, together with the average.

The load required to break each specimen that was subjected to heat treatment, together with the average.

The percentage loss of strength due to heat treatment calculated from the two averages.

Porosity

Moisture Absorption

Any good chemical balance, a beaker of distilled water at normal room temperature of about 20 deg. C. (68 deg. F.) and an oven of any standard make capable of maintaining a uniform temperature at the desired point within + or — 5 deg. C. shall be provided.

A single piece of porcelain shall be used weighing from 30 to 50 g. and with at least 50 per cent. of the surface newly fractured.

The specimen shall be dried for 24 hours at 120 deg. C. (248 deg. F.), cooled in a desiccator and weighed. The specimen shall then be totally submerged in the distilled water at room temperature (about 20 deg. C.) and allowed to remain submerged for 100 hours. The water shall be boiled for approximately one hour during the first, twenty-fifth, forty-ninth and seventy-third hours. The specimen shall be removed at the end of the 100-hour period, the surface moisture carefully dried off with a clean, dry cloth and the specimen weighed.

The report shall include the following:

The original weight of the specimen;

The dry weight of the specimen;

The dry weight of the specimen after immersion for 100 hours;

The percentage of moisture content in each specimen as received and the percentage of moisture absorbed during the 100 hours, taking the dry weight as 100 per cent., and the average where more than one specimen is tested.

Penetration of Dye

A closed receptacle containing an alcoholic dye solution and a pump with which a pressure up to 600 lb. per sq. in. can be maintained in the receptacle shall be provided.

A single specimen of porcelain shall be used, weighing at least 30 g. and with at least 50 per cent. of the surface newly fractured. This specimen may be taken from any piece of finished ware, but if the piece varies materially in thickness (as, for example, in a transmission line insulator), a specimen shall be taken from both the thinnest and the thickest portions.

The specimen shall be immersed for two hours in a saturated methol alcoholic solution of eosin or fuchsine at a pressure of not less than 200 lb. per sq. in. nor more than 600 lb. per sq. in. at a room temperature of about 20 deg. C. (68 deg. F.).

The report shall include a statement of the maximum depth of the penetration of the dye toward the interior of the specimen from the fractured surface exposed to the solution. (Lines of penetration along obvious cracks caused by possible fracturing are to be disregarded.)

242—ELEVATOR BOLTS

Sizes of the Flat-Headed Type Carried by Supply Houses—Length Under Head and Diameter of Shank, Both in Inches

1/2 x 3/16	1 x 1/4	3/4 x 5/16	1 x 3/8
5/8 x 1/4	1 1/4 x 1/4	7/8 x 5/16	1 1/4 x 3/8
3/4 x 1/4	1 1/2 x 1/4	1 x 5/16	1 1/2 x 3/8
7/8 x 1/4	....	1 1/4 x 5/16	....
....	....	1 1/2 x 5/16	....

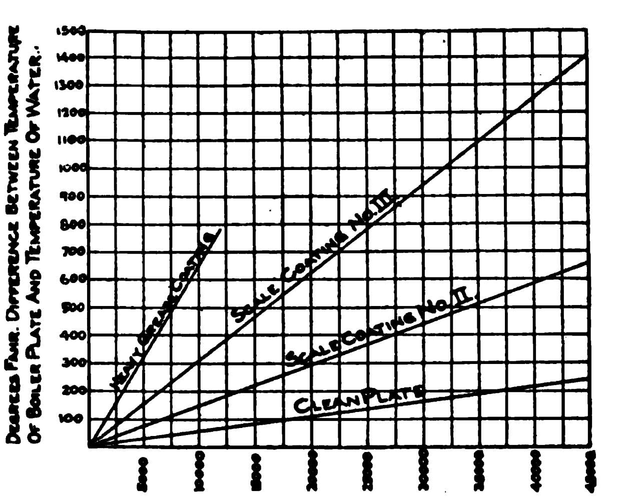
The attached table showing thicknesses of belt in inches of the various plies and the various materials affords information on which to base the proper length of elevator bolt.

No. of Plies	Leather	Rubber	Cotton	Canvas Stitched
Single	5/32 to 1/4	....	....	....
Double	5/16 to 1/2	....	....	....
2	....	1/8	1/8	....
3	....	3/16	5/32	3/16
4	....	1/4	3/16	5/16
5	....	5/16	7/32	7/16
6	....	3/8	1/4	9/16
8	....	1/2	....	11/16

The thickness of the nut of an elevator bolt is approximately the same as the diameter of the bolt.

58—BOILER COMPOUND

The attached table shows the heat that must be attained by a boiler shell in order to transmit a given amount of heat units to the water inside of the boiler. A clean plate will transmit 17,500 B. t. u. per hour per sq. ft. of boiler surface with the sheet only 100 deg. higher in temperature than the water, or 312 deg. A boiler with a



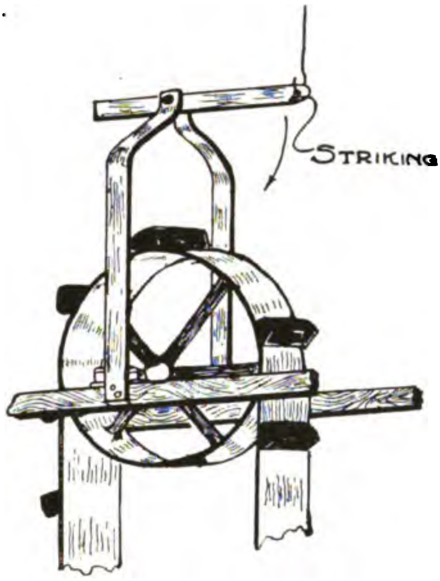
EFFECT OF SCALE ON HEAT TRANSMISSION

heavy greasy coating or scale will transmit 12,500 B. t. u. with an increase of 800 deg. in the temperature of the shell over that of the water. In other words, the shell would have a temperature of 1,012 deg. It is easy to see why bags are caused in boilers that are afflicted with a bad scale. Boiler compounds aim to soften this scale so that it can be removed easily.

Courtesy H. S. B. W.—Cochrane Corporation.

245—ELEVATOR OR BUCKET CONVEYOR

The attached cut shows a method of cleaning sticky clay from elevator buckets. Some provision must be made to move the rod up and down so that it will strike each bucket.



Attachment for Cleaning Elevator Buckets

Horse Power of Elevators

The following formula allows 100 per cent. for friction and is found to give very conservative results;

$$\text{Horsepower required for elevators} = \frac{H \times T}{500}$$

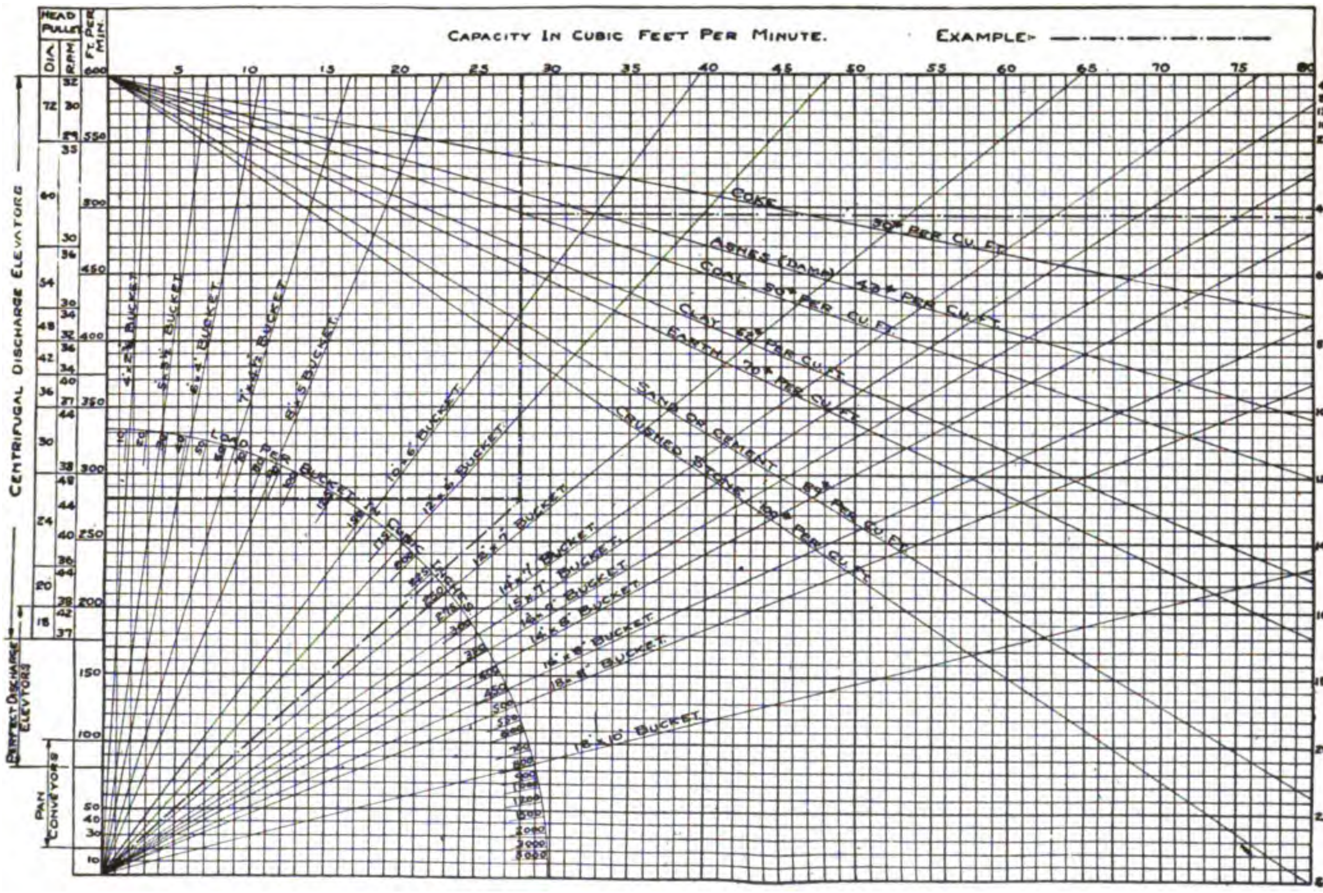
where H=height of lift in feet.
T=tons per hour.

Searle gives the attached table to determine the cubic feet that an elevator will deliver per hour, when the capacity of the buckets in cubic inches and the speed of the elevator are known. The speed is shown in the number of buckets that will pass a certain point in a minute.

Cubio Feet Elevator Capacity

Capacity of buckets. Cubic ins.	Number of buckets per minute.									
	60	70	80	90	100	125	150	175	225	275
10	20·8	24·3	27·8	31·2	34·7	43·4	52·1	60·8	78·1	95·5
15	31·2	36·4	41·7	46·9	52·1	65·1	78·1	91·1	117	143
25	52·1	60·8	69·4	78·1	86·8	108	130	152	195	239
35	72·9	85·1	97·2	109	121	152	182	213	273	334
45	93·7	109	125	141	156	195	234	273	351	430
60	125	146	167	187	208	260	312	365	469	573
75	156	182	208	234	260	325	391	456	586	716
100	208	243	278	312	347	434	521	608	781	956
125	260	304	347	390	434	542	651	759	976	1193
175	364	425	486	547	608	760	911	1063	1367	1671
225	469	547	625	703	781	976	1172	1367	1758	2147
275	573	668	764	859	955	1193	1432	1670	2142	2625
325	677	790	903	1015	1128	1410	1692	1975	2538	3102
375	781	911	1042	1172	1302	1627	1953	2279	2929	3580

The attached chart shows the size of bucket, diameter and speed of head pulley, etc.



NOTE: Chart is based on buckets spaced 16 inches. Buckets recommended by the table are Style "A" and are figured ⅔ full. For other types of buckets refer to quadrant which gives capacity to be carried by each bucket rather than total capacity of bucket.

EXAMPLE— To handle 42 tons of coal per hour at speed of 280 feet per minute—Enter chart at right, move horizontally to coal diagonal, thence down to required speed of 280. This intersection shows a 12x7 Style A bucket to be suitable or any bucket which will carry 235 cubic inches. Use 24-inch head pulley at 44 R. P. M.

Chart to Determine Size of Bucket for Various Speeds and Loads

From Stephens-Adamson Mfg. Co.

251—EXPANSION JOINT FOR PIPING

Expansion of Steam Pipes

The linear expansion and contraction of pipe, due to differences of temperature of the fluid carried and the surrounding air, must be cared for by suitable expansion joints or bends.

In order to determine the amount of expansion or contraction in a pipe line, we give below a table showing the increase in length of a pipe 100 feet long at various temperatures.

EXPANSION OF PIPE
INCREASE IN LENGTH—INCHES PER 100 FEET

Temperature, Degrees F	Steel	Wrought Iron	Cast Iron	Brass and Copper
0	0	0	0	0
20	15	.15	.10	.25
40	.30	.30	.25	.45
60	.45	.45	.40	.65
80	.60	.60	.55	.90
100	.75	.80	.70	1 15
20	.90	.95	.85	1.40
40	1.10	1.15	1.00	1.65
60	1.25	1.35	1.15	1.90
80	1.45	1.50	1.30	2.15
200	1.60	1.65	1.50	2.40
20	1.80	1.85	1.65	2.65
40	2.00	2.05	1.80	2.90
60	2.15	2.20	1.95	3.15
80	2.35	2.40	2.15	3.45
300	2.50	2.60	2.35	3.75
20	2.70	2.80	2.50	4.05
40	2.90	3.05	2.70	4.35
60	3.05	3.25	2.90	4.65
80	3.25	3.45	3.10	4.95
400	3.45	3.65	3.30	5.25
20	3.70	3.90	3.50	5.60
40	3.95	4.20	3.75	5.95
60	4.20	4.45	4.00	6.30
80	4.45	4.70	4.25	6.65
500	4.70	4.90	4.45	7.05
20	4.95	5.15	4.70	7.45
40	5.20	5.40	4.95	7.85
60	5.45	5.70	5.20	8.25
80	5.70	6.00	5.45	8.65
600	6.00	6.25	5.70	9.05
20	6.30	6.55	5.95	9.50
40	6.55	6.85	6.25	9.95
60	6.90	7.20	6.55	10.40
80	7.20	7.50	6.85	10.95
700	7.50	7.85	7.15	11.40
20	7.80	8.20	7.45	11.90
40	8.20	8.55	7.80	12 40
60	8.55	8.90	8.15	12 95
80	8.95	9.30	8.50	13 50
800	9.30	9.75	8.90	14.10

The expansion for any length of pipe may be found by taking the difference in increased length at the minimum and maximum temperatures, dividing by 100 and multiplying by the length of the line under consideration.

263—FIRE BRICK

The following definitions are excerpts from the standard definitions adopted by the American Society for Testing Materials for refractories made of fire clay.

High Heat Duty Brick

Clay Fire Brick

(Silica content less than 70 per cent.) The softening point of clay fire brick for high heat duty shall not be lower than that of standard cone No. 31 (about 1685 deg. C., or 3065 deg. F.).

When duplicate samples of clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400 deg. C. (2552 deg. F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent. of the original length nor an expansion of more than 1 per cent.

When a brick of this type softens at a temperature not below the softening point of standard cone No. 29 (about 1650 deg. C., or 3002 deg. F.), it may be tested according to classification (B) for silicious clay fire brick without losing in standing if it passes the tests.

Silicious Clay Fire Brick

(Silica content 70 per cent. or over.) The softening point of silicious clay fire brick for high heat duty shall not be lower than that of standard cone No. 28 (about 1635 deg. C., or 2975 deg. F.).

All silicious clay fire brick for high heat duty shall be subjected to a load test in accordance with the requirements of the Standard Test for Refractory Materials under Load at High Temperatures. (See statistical entry under Refractories.) The pressure to be applied upon the brick (placed on end) shall be 25 lb. per sq. in. and the maximum furnace temperature 1350 deg. C. (2462 F.). The brick shall not show a contraction of more than 4 per cent. of the original length, nor an expansion of more than 1 per cent.

When duplicate samples of silicious clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400 deg. C. (2552 deg. F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

Intermediate Heat Duty Brick

The softening point of brick for intermediate heat duty shall not be lower than that of standard cone No. 28 (about 1635 deg. C., or 2975 deg. F.).

When duplicate samples of brick for intermediate heat duty are heated uniformly in a suitable furnace to a temperature of 1350 deg. C. (2462 deg. F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent. of the original length nor an expansion of more than 1 per cent.

Moderate Heat Duty Brick

The softening point of brick for moderate heat duty shall not be lower than that of standard cone No. 26 (about 1600 deg. C., or 2912 deg. F.).

When duplicate samples of brick for moderate heat duty are heated uniformly in a suitable furnace to a temperature of 1290 deg. C. (2354 deg. F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent. of the original length nor an expansion of more than 1 per cent.

Low Heat Duty Brick

The softening point of brick for low heat duty shall not be lower than that of standard cone No. 19 (about 1510 deg. C., or 2750 deg. F.).

Further tests and definitions will be found under the remaining entries of this item and also under Refractories, page 190.

Softening Point

The American Society for Testing Materials has adopted the following standard test for the softening point of fire clay brick:

The object of this test is to determine the softening point of fire clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

A 1-kg. (2-lb.) sample shall be taken by chipping off approximately equal portions from the corners of the brick. These fragments shall be reduced in size by means of rolls or a jaw crusher adjusted to pass a lump 6 mm. (¼ in.) in diameter. They shall be mixed thoroly, and the amount of material reduced to about 250 g. (.5 lb.) by quartering. A magnet shall be repeatedly passed thru the crushed material until all particles of metallic iron are removed. This portion shall be ground in a porcelain

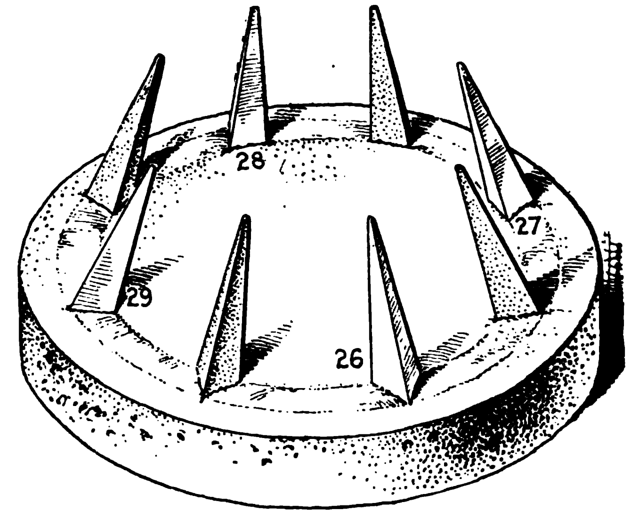


Fig. 1.

or agate mortar to pass a 60-mesh Standard sieve (diameter of wire 0.185 mm., opening 0.25 mm.). In order to avoid excessive reduction of the fines, they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass thru the sieve.

The sample thus prepared shall be thoroly mixed and after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. ($\frac{3}{16}$ in.) on the sides at the base and 25 mm. (1 in.) high.

When dry the test cones may be subjected to a preliminary burn at a temperature not exceeding 1300 deg. C. (2372 deg. F.) for the purpose of sintering them into a firm condition to permit handling.

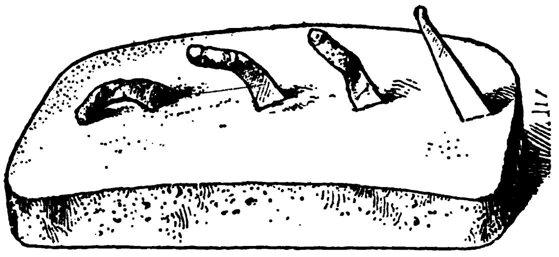


Fig. 2

The test cones shall be mounted on plaques of refractory material of such a composition as will not affect the fusibility of the cones. A mixture of equal parts of a highly refractory clay, such as a good grade of china clay, and fused alumina which will pass a 100-mesh sieve, has been found satisfactory. They shall be mounted with the base embedded approximately 1 mm. (0.04 in.) in the plaque and the face of one side inclined at an angle of 75 deg. with the horizontal. The arrangement with respect to the Orton cones shall be substantially as shown in Fig. 1, that is, alternating with the Orton cones in such a way that Orton cones of successive numbers will be placed opposite each other. The plaque may be any convenient size and shape and may be biscuited before using, if desired.

The heating shall be done in a suitable furnace at a rate not greater than 15 deg. C. (27 deg. F.) per minute, nor less than 10 deg. C. (18 deg. F.) per minute after cone No. 1 is reached, or as nearly within these limits as possible.

That type of furnace in which a neutral or oxidizing atmosphere may be maintained is to be preferred. Excessive reducing conditions should be avoided. Care should be taken that the flame does not strike directly against the cone or cone plaque. The furnace should be tested at intervals for the determination of the uniformity of the distribution of the heat.

The softening of the cone will be indicated by the top bending over and assuming the position shown in Fig. 2. The bloating, squatting or unequal fusion of small constituent particles should always be reported. The softening point shall be reported in terms of Orton cones and shall be that cone which most nearly corresponds in time of softening with the test cone. If the test cone softens later than one Orton cone but earlier than the next Orton cone and approximately midway between, the softening point shall be reported thus: Cone No. 31-32.

If the test cone starts bending at an early cone but is not down until a later cone, the fact should be reported.

Spalling Test

The American Society for Testing Materials has suggested the following tentative method of test for resistance of fire clay brick to spalling action.

The object of this test is to determine the resistance of high-duty fire clay brick to spalling action, by subjecting them to repeated rapid temperature changes.

The sample shall consist of at least five standard 9-in. brick or of five shapes, which may be cut to standard size with a grinding wheel.

Test specimens of shapes such as boiler arch brick shall be cut to the standard 9-in. size. For this purpose a "cut-off" wheel is recommended.

The test specimens shall be marked for identification and then subjected to a preliminary heat treatment by heating them uniformly in a suitable furnace to a temperature of 1400 deg. C. (2552 deg. F.), maintaining this temperature for five hours, and then allowing them to cool.

The specimens shall be weighed and placed in a door of a furnace operated at 1350 deg. C. (2462 deg. F.), care being taken to prevent the direct heating of more than the 2½ by 4½-in. end. After one hour the specimen shall be withdrawn from the furnace and stood on end in a tank of flowing cold water from 10 to 21 deg. C. (50 to 70 deg. F.) so that the hot end of the brick will be immersed to a depth of 4 in. After three minutes the sample shall be withdrawn from the water, allowed to steam five minutes and then returned to the furnace. The door of the furnace shall be closed while the brick are out to prevent the lowering of the temperature. The alternate heating and cooling shall be continued in hourly cycles until the end of the brick spalls off.

When pieces begin to fall off, the sample is laid on a 4.5 by 9.0-in. asbestos board, divided into one hundred equal squares, and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick is again weighed and the percentage of loss determined.

As an alternate for water dipping, air cooling may be used. This method should be used where the spalling is too rapid to get comparative results by the water dipping method. In this case the hot end of the brick shall be placed facing the air blast, 4 in. from the end of a 2-in. pipe from a ¼-h. p. blower, delivering between 28 and 30 cu. ft, of air per minute.

The report shall show the number of dips before loss started, the percentage of loss after each cooling, the total number of dips and the final percentage of loss by weight.

The Effect of Slag on Fire Clay Brick

The work here presented was carried out for the purpose of determining the action of various slags at different temperatures on several standard brands of fire brick.

The general plan was to secure brick of recognized quality and to test the action of several slags upon them at different temperatures. The method used for determining this action was essentially the same as is used by the Carnegie Steel Co. At that laboratory a brick is heated to a definite temperature and 35 grams of slag are placed in a cavity at that temperature and are allowed to act for two hours.

Table I. Influence of Time and Quantity of Slag Used Upon Results Secured from Slag Tests

Penetration of 35 grams of slag in two hours	.64
Penetration of 35 grams of slag in four hours	.68
Penetration of 35 grams of slag in six hours	.64
Penetration of 105 grams of slag in two hours	.76
Penetration of 105 grams of slag in four hours	.72

Before adopting this method certain points were checked pertaining chiefly to the influence of the time of action, and the quantity of slag used, upon the results secured. Tests were made in which the time and slag were trebled, but this procedure failed to produce a more pronounced action upon the cavity in the brick. In reporting the results, the total cross-section of the slag saturated area was first measured by means of a planimeter. The area of the original cavity was then sub-

Table II. Analyses and Fusion Points of Slag Tests

Slag	Blast Furnace	Heating Furnace	Basic Open Hearth	Acid Open Hearth	Zinc	Copper
Silica	37.32	34.16	18.42	46.48	34.30	28.20
Alumina	13.21	6.13	3.85	5.45	14.74	2.20
Iron	1.62	43.60	14.55	29.30	21.00	2.10
Lime	42.20	1.30	44.10	2.16	2.33	2.51
Magnesia	2.35	.65	6.32	.00	7.07	2.14
Manganese	1.11	.55	5.09	9.08	6.77	.00
Sulphur	1.20	.27	.42	.38	5.88	.14
Phosphorus	.00	.02	.58	.00	.02	.24
Copper	.00	.00	.00	.00	1.28	58.21
Zinc	.00	.00	.00	.00	8.20	.00
Melting point	1220 deg. C.	1050 deg. C.	1275 deg. C.	1400 deg. C.	1025 deg. C.	1020 deg. C.

tracted from this. The difference represented the area of the section which had been penetrated by the slag. This area when divided by the linear surface of contact gave a value which represented the square inches of penetration per inch of contact.

Tests Showing Influence of Temperature of Slag Upon Life of Fire Brick

The results given in Table I confirmed those reported by Nesbitt and Bell and lead to the same conclusions, that is, when a brick having a cavity 2½ inches in diameter is treated with 35 grams of slag and it is allowed to react for two hours satisfactory results are obtained. In the preceding work 35 grams of slag reacting for two hours resulted in a penetration value of 0.64. When the severity of this test was increased 600 per cent., the penetration factor increased but 12.5 per cent.

In view of this preliminary work, the following definite method of procedure was adopted. The test brick, each having two cavities 2½ inches in diameter by ½ inch in depth, were heated slowly to the temperature at which the test was to be made. This temperature was held for 1½ hours. Thirty-five grams of slag were then introduced and were allowed to react at this temperature for 2 hours. The brick were then allowed to cool, were cut thru the center of the cavities, and the penetration was noted in the manner previously described.

Six slags, which were secured from the Carnegie Steel Co.'s laboratory, were used during the tests. Their analyses and fusion points are given in Table II. The three brick used are designated by A, B, and C.

By following the method already described and varying the brick, the slag and the temperature, one at a time, the average results shown in Tables III, IV, V, VI, VII and VIII were secured.

In each case the slag penetrated more deeply into the brick at higher temperatures. In several cases an increase of 100 deg. C. or less than 10 per cent. resulted in nearly doubling the penetration.

Table III. Penetration of Heating Furnace Slag, Melting Point 1,050 Deg. C.

Brick	Temperature of Test			
	1150 degree C.	1250 degree C.	1350 degree C.	1450 degree C.
Type A	.04	.09	.15	.34
Type B	.02	.05	.11	.79
Type C	.07	.10	.24	.78

Table IV. Penetration of Blast Furnace Slag, Melting Point 1,220 Deg. C.

Brick	Temperature of Test		
	1250 degree C.	1350 degree C.	1450 degree C.
Type A	.03	.08	.14
Type B	.00	.11	.17
Type C	.07	.12	.17

Table V. Penetration of Zinc Slag, Melting Point 1,025 Deg. C.

Brick	Temperature of Test			
	1150 degree C.	1250 degree C.	1350 degree C.	1450 degree C.
Type A	.03	.13	.28	.19
Type B	.04	.16	.29	.32
Type C	.05	.24	.33	.43

Table VI. Penetration of Basic Open-Hearth Slag, Melting Point 1,275 Deg. C.

Brick	Temperature of Test	
	1350 degree C.	1450 degree C.
Type A	.58	.73
Type B	.29	.33
Type C	.44	.55

Table VII. Penetration of Acid Open-Hearth Slag, Melting Point 1,400 Deg. C., at 1,450 Deg. C.

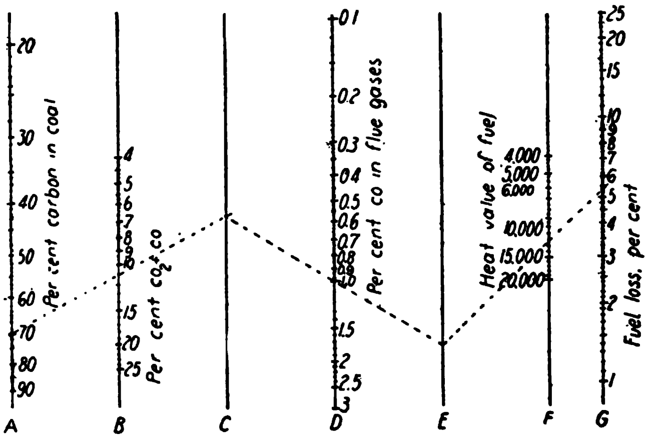
Brick	Penetration
Type A	.24
Type B	.33
Type C	.57

Table VIII. Penetration of Copper Slag, Melting Point 1,020 Deg. C.

Brick	Temperature of Test	
	1150 degree C.	1250 degree C.
Type A	.46	.65
Type B	.36	.57
Type C	.52	.62

272—FLUE GAS ANALYSIS APPARATUS

Air contains 21 per cent. oxygen and 79 per cent. nitrogen by volume. When just the exact theoretically required amount of air is used for burning pure carbon the volume of carbon dioxide produced will be equal to the volume of oxygen used and the resultant gases will consist of 21 per cent. carbon dioxide and 79 per cent. nitrogen. If an excess of air is supplied, the products of combustion will be greater in volume by the amount of excess air and will contain the excess of oxygen. The proportion of carbon dioxide will be decreased in proportion to the excess air supplied and the composition of the gases will be 79 per cent. nitrogen and 21 per cent. carbon dioxide and oxygen combined. If the amount of excess air is 100 per cent., that is, equal to the amount theoretically required, the products of combustion will contain 10.5 per cent. carbon dioxide, 10.5 per cent. oxygen and 79 per cent. nitrogen but the total volume of the products will be twice as great as in the case of only the theoretically required amount of air.



By the Use of This Chart, You Can Determine the Percentage of Your Fuel Loss Due to an Excess of Carbon Monoxide in the Flue Gases

Bituminous coal is the most commonly used fuel in the firing of kilns. The combustible constituents are carbon, hydrogen and sulphur. These combine with the oxygen of the air to form carbon dioxide, steam and sulphur dioxide. The products of combustion in ordinary practice will contain these three gases together with some excess oxygen and nitrogen from the air supplied. In the analysis of the flue gases only carbon dioxide (including the sulphur dioxide), oxygen and nitrogen will appear. The proportions of these will vary with the amount of excess air supplied for the combustion and this will also determine the quantity of the flue gases.

As an illustration, consider the combustion of a bituminous coal having the analysis—carbon, 60 per cent.; hydrogen, 4 per cent.; oxygen, 6 per cent.; nitrogen, 2 per cent.; sulphur, 4 per cent.; ash, 10 per cent.; moisture, 14 per cent. by weight. This may be considered as fairly representative of middle western coals of this type. Considering only the carbon content of this coal, the consumption per pound theoretically would require 108.3

cu. ft. of dry air, measured at 70 deg. F. and 30 inches barometric pressure. Theoretically perfect combustion would produce 19.4 cu. ft. of carbon dioxide (assuming one-half the sulphur is burned), and 85.8 cu. ft. of nitrogen, all measured at the same temperature and pressure. A gas analysis (dry gases) would show 18.6 per cent. carbon dioxide and 81.4 per cent. nitrogen. (It is to be noted that the proportion of carbon dioxide in the flue gases from such a fuel is less than that obtained in burning pure carbon.)

The percentage of excess air when burning bituminous coal equals

$$100\times\frac{100}{5.5\times\text{per cent. of carbon dioxide}}-1$$

It should not be expected that combustion can be maintained with just the theoretically required amount of air supplied. In all furnaces it is necessary to admit a certain amount of excess air to insure thoro combustion of the fuel. In general, the amount of this necessary excess ranges from 50 to 100 per cent. altho under exceptional conditions somewhat less may be safely used. For efficient combustion we may expect to have 9 to 13 per cent. carbon dioxide in the flue gases. A less amount indicates too great an excess of air while more than 13 per cent. may be accompanied by some carbon monoxide and a tendency to reducing conditions.

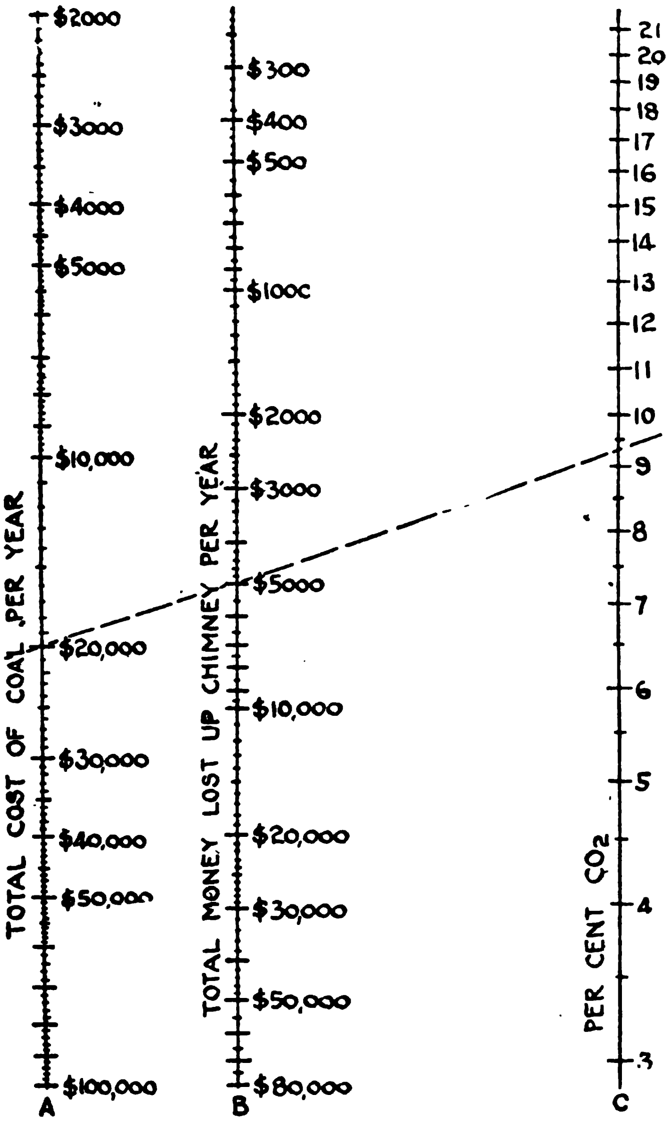


Chart Showing Total Possible Loss in Coal When Value of CO_2 is Known

Fuel Losses Due to Carbon Monoxide

To explain the operation of the first chart we will take as an example a coal that contains 70 per cent. of carbon, the flue gases of which contain ten per cent. carbon dioxide (CO_2) and one per cent. carbon monoxide (CO). The heat value of the coal is 12,000 B.t.u.'s per pound. In determining the fuel losses in this case, a line is run from column "A" at seventy, thru column "B" at eleven (the sum of the percentages of CO_2 and CO), and continued until it intersects the line "C." From the point of intersection, run the line thru the percentage of CO as shown in column "D," and strike a point on column "E." From this point draw the line thru the heat value of the coal as shown in column "F" which, in this case, amounts to 12,000 B.t.u.'s a pound, and the intersection with the column "G" gives the percentage of fuel loss. Under the conditions outlined here, a fuel loss of 5.4 per cent. would be suffered. The method of using the chart is extremely simple for the line is carried directly across from left to right.

Table I.

Behavior of the Elements That Effect the Composition of the Flue Gases

Name of the Element	Chemical Symbol of the Element	What Takes Place in the Furnace	Combines with Oxygen to Form	Proportion of Oxygen Required to Burn	Pounds of Air Required to Burn One Pound	Resultant Heat From Complete Combustion of One Pound
Carbon...	C	burns	CO_2	2.66	11.57	14,000
Hydrogen	H	burns	H_2O	8.0	34.80	62,000
Oxygen...	O	does not burn	....	....:....	....	....
Nitrogen .	N	does not burn	....	....	....	....
Sulphur..	S	burns	SO_2	1.0	4.35	4,050

Table II.

Cooling Effects of Various Percentages of Excess Air

Percentage excess air	Theoretical temperature of combustion deg. Fahr	Loss of temperature due to excess of air deg. Fahr.	Loss expressed in terms of percentage	Relative boiler capacity, assuming 40% excess air as normal attainable practice pr 100 %
0	5132	0	0	......
10	4710	422	8.2	......
20	4352	780	15.2	......
30	4044	1088	21.2	......
40	3777	1355	26.4	100
50	3543	1589	31.0	93.5
60	3336	1796	35.0	88.2
70	3153	1979	38.6	83.0
80	2988	2144	41.4	78.5
90	2840	2292	46.7	74.5
100	2705	2927	47.3	70
125	2419	2713	52.9	63
150	2188	2944	57.4	56.6
175	1997	3135	61.1	51.5
200	1837	3295	64.2	47.0

Table III.

Percentages of Losses in Calorific Value of the Coal as Fired Due to Various Causes

Heat absorbed and losses itemized.	Highest attainable efficiency	Excellent practice	Good practice	Average practice	Poor practice
Heat absorbed by boiler..........	89.86	80.0	75.0	65.0	60.0
Loss due to free moisture on coal	0.50	0.5	0.6	0.6	0.7
Loss due to hydrogen in coal (evaporation of H_2O)	4.20	4 20	4.30	4.3	4.4
Loss due to heat in dry flue gases	5.33	10.0	13.0	17.5	20.0
Loss due to carbon monoxide....	0.00	0 2	0.3	0.5	1.0
Loss due to combustible in ash and refuse	0 00	1.5	2 4	4.5	5.5
Loss due to heating moisture in air	0 11	0 2	0.2	0.3	0.4
Loss due to unconsumed hydrogen, hydrocarbon, radiation and unaccounted for	0.00	3.4	4.2	7.3	8.0
Calorific value of coal.....	100%	100%	100%	100%	100%

The range of the chart is wide enough to take care of nearly every condition of flue gases. Should the intersection with column "C" or "E" fall outside of the chart it is only necessary to extend the lines and proceed with the problem. A little study given to the chart and the solution of a few original problems will soon show that the percentage of CO should be as low as possible and that the CO_2 content should be as high as possible.

This chart is based on the following method: the percentage of carbon in the coal is divided by the sum of the percentages CO_2 and CO. This result is multiplied by the percentage of CO, divided by the heat units of the coal per pound and multiplied by 10,150.

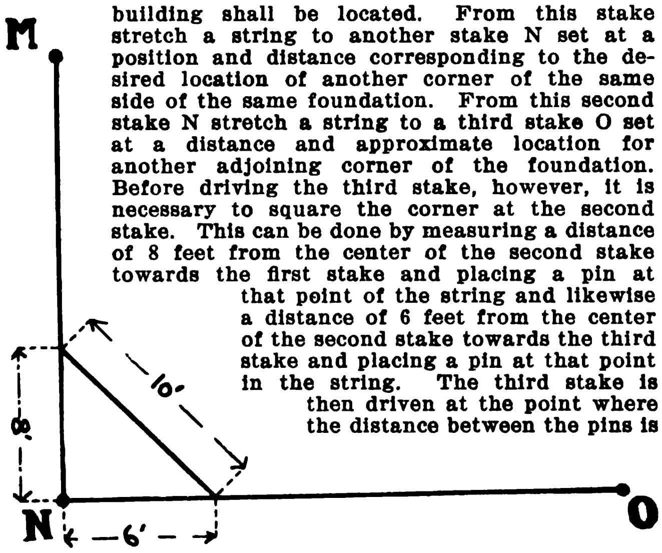
The second chart shows the total possible loss in the second column when the total cost of fuel for the year and the percentage of CO_2 is known. It is principally a good evidence of the possible saving when CO_2 is kept as low as possible.

278—FOUNDATIONS

Bearing Power of Soils

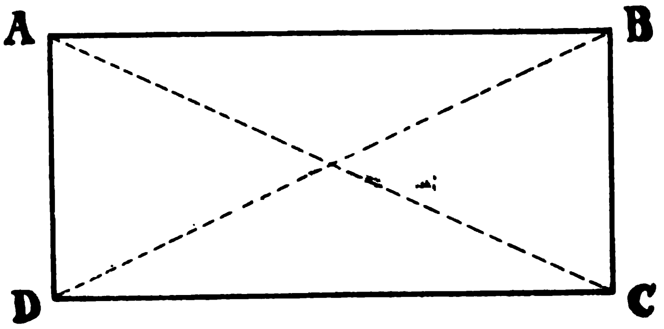
	Bearing power in tons per square foot Minimum	Maximum
Rock—the hardest in thick layers, in native bed	200	
Rock equal to best dressed stone masonry	25	30
Rock equal to best brick masonry	15	20
Rock equal to poor brick masonry	5	10
Clay on thick beds, always dry	4	6
Clay on thick beds, moderately dry	2	4
Clay, soft	1	2
Gravel and coarse sand, well cemented	8	10
Sand, compact, and well cemented	4	6
Sand, clean, dry	2	4
Quicksand, alluvial soil, etc.	0.5	1

A good method of laying out the corners of a building without the use of an instrument is as follows: Set a stake M where it is desired one corner of the building shall be located. From this stake stretch a string to another stake N set at a position and distance corresponding to the desired location of another corner of the same side of the same foundation. From this second stake N stretch a string to a third stake O set at a distance and approximate location for another adjoining corner of the foundation. Before driving the third stake, however, it is necessary to square the corner at the second stake. This can be done by measuring a distance of 8 feet from the center of the second stake towards the first stake and placing a pin at that point of the string and likewise a distance of 6 feet from the center of the second stake towards the third stake and placing a pin at that point in the string. The third stake is then driven at the point where the distance between the pins is 10 feet when both strings are in a straight line. Other corners are located in the same way.



Method of Laying Out a Square Corner

A check on any foundation can be made by measuring the distances from opposite corners of any rectangle as shown in the sketch. If the corners are square the distance AC will be equal to the distance BD, when AB equals CD and BC equals AD.



Method of Checking a Foundation for Square Corners

Stack Foundations

The Philadelphia Engineering Works gives the following data on foundations for self-sustaining steel stacks, half-lined:

	CLEAR DIAMETER, IN FEET						
	3	4	5	6	7	8	9
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
Height	100...	100...	150...	150...	150...	175...	225...
Least diameter of foundation	15 9	15 3	20 4	21 10	22 7	25 9	29 11
Least depth of foundation	6 6	7...	9...	8...	9...	10...	13...
Height	......	125...	200...	200...	250...	275...	300...
Least diameter of foundation	......	17 6	23 8	25...	29 8	33 6	36 6
Least depth of foundation	......	7 6	10...	10...	12...	12...	14...

See also (statistical entries) Concrete and Kilns, down draft, design and construction.

281—FRIT

The following frits (melted and reground glazes) are stated by E. Berdell to be non-poisonous, altho they contain a good percentage of lead.

0.10 Na_2O 0.15 K_2O 0.75 Pb O	0.15 Al_2O_3	2.50 Si O_2 0.40 B_2O_3	Glazes melt at cone 022 to 020
0.30 Na_2O 0.20 K_2O 0.50 Pb O	0.15 Al_2O_3	2.55 Si O_2 0.45 B_2O_3	
0.20 Na_2O 0.30 K_2O 0.50 PbO	0.15 Al_2O_3	2.55 Si O_2 0.45 B_2O_3	
0.15 Na_2O 0.15 K_2O 0.60 PbO 0.10 BaO	0.15 Al_2O_3	2.45 Si O_2 0.45 B_2O_3	Glazes melt at cone 020 to 016
0.15 Na_2O 0.15 K_2O 0.60 Pb O 0.10 Ba O	0.15 Al_2O_3	2.45 Si O_2 0.50 B_2O_3	
0.10 Na_2O 0.15 K_2O 0.65 Pb O 0.10 Ba O	0.15 Al_2O_3	2.50 Si O_2 0.40 B_2O_3	
0.8 Pb O 0.2 Ba O	0.15 Al_2O_3	2.50 Si O_2 0.40 B_2O_3	Glazes melt at cone 015
0.9 Pb O 0.1 Ba O	0.15 Al_2O_3	2.50 Si O_2 0.40 B_2O_3	
0.85 Pb O 0.15 Ba O	0.15 Al_2O_3	3.05 Si O_2 0.40 B_2O_3	Glazes melt at cone 05
0.9 Pb O 0.1 Ba O	0.15 Al_2O_3	3.05 Si O_2 0.40 B_2O_3	

286—FUELS, COMPARISON OF

Formulas for Fuel Comparison

Aside from any difference in the labor used, in the turnover of equipment or in the investment—taking into account only the heat values of two fuels use the following formulas:

$$\text{For coal } \frac{A}{2{,}000\ B} = C$$

$$\text{For fuel oil} \frac{D}{E\ F\ G} = H$$

in which

A=Cost of coal delivered at the point of use.
B=B.t.u. per pound for the coal under consideration.
C=Average cost of each B.t.u. in the coal.
D=cost of a barrel of fuel oil delivered at the point of use.
E=B.t.u. per pound of oil.
F=Number of pounds of oil to the gallon.
G=Number of gallons to a barrel.
H=Average cost of each B.t.u. in the oil.

Take a coal costing $4.50 per ton with 12,500 B.t.u. per pound, and compare with oil costing $1.10 per barrel of 42 gallons, having a heat value of 21,000 B.t.u. per pound and weighing 7.7 pounds per gallon. The formulas become

$$\frac{\$4.50}{2{,}000\times 12{,}500=25{,}000{,}000}=0.000{,}000{,}18$$

Cost of one B.t.u. from coal.

$$\frac{\$1.10}{21{,}000\times 7.7\times 42=6{,}791{,}400}=0.000{,}000{,}162$$

Cost of one B.t.u. from oil.

In comparing the costs for any two fuels the costs of operation and the investment must be taken into account, in addition to the difference in fuel value as shown above.

Amounts of Different Fuels for Equal Heat Units

Oil Gallon	Coal Pounds	Natural Gas Cubic Feet	Coal Gas Cubic Feet	Bituminous Producer Gas-Cubic Feet	Anthracite Producer Gas-Cubic Feet	Total B. T. U.
1.	12.	144	230	986	1035	144000
167.	2000.	24000	38400	164000	173000	24000000
6.95	83.5	1000	1600	6850	7180	1000000
4.34	52.1	625	1000	4280	4500	625000
1.02	12.2	146	235	1000	1055	146000
.97	11.6	139	222	953	1000	139000

Figured on a basis of—

Coal, 12,000 BTU per pound.
Oil, 14,400 BTU per gallon.
Natural Gas, 1,000 BTU per cu. ft.
Coal Gas, 625 BTU per cu. ft.
Bit. Producer Gas, 146 BTU per cu. ft.
Anthra. Prod. Gas, 139 BTU per cu. ft.

If your coal, oil or gas has a different value, the corresponding amount from the table can be figured by a simple proportion.

Table of B.t.u.'s That One Dollar Will Buy

Fuel	Basis	B.T.U.
Bituminous Coal...	13,500 B.T.U. per Lb....... 2,000 Lb. @ $4.00.	6,750,000
Anthracite Coal....	13,500 B.T.U. per Lb....... 2,000 Lb. @ $8.00.	3,375,000
Seasoned Hardwood	4,000 B.T.U. per Lb........ $8.00 per 4-Ft. Cord.	2,700,000
Natural Gas.......	1,000 B.T.U. per Cu. Ft..... $0.30 per 1,000 Cu. Ft.	3,333,000
City Gas..........	600 B.T.U. per Cu. Ft...... $1.00 per 1,000 Cu. Ft.	600,000
Crude Oil..........	19,000 B.T.U. per Lb....... $4.00 per Bbl.	1,615,000
Electricity.........	8 cents per Kw.-Hr......... 1 cent per Kw.-Hr..........	4,266 34,128
Alcohol............	95% volume, $1.00 per Gal. (6.58 Lbs.)..............	78,302

285—FUEL OIL

Data on Fuel Oil

The table attached gives the specific gravity corresponding to each degree of Baumé Hydrometer, also the number of pounds. contained in one United States gallon at 60 deg. F.

Baumé Degree	Specific Gravity Degree	In One Gallon Pounds	Baumé Degree	Specific Gravity Degree	In One Gallon Pounds
10	1.0000	8.33	43	0.8092	6.74
11	0.9929	8.27	44	0.8045	6.70
12	0.9859	8.21	45	0.8000	6.66
13	0.9790	8.16	46	0.7954	6.63
14	0.9722	8.10	47	0.7909	6.59
15	0.9655	8.04	48	0.7865	6.55
16	0.9589	7.99	49	0.7821	6.52
17	0.9523	7.93	50	0.7777	6.48
18	0.9459	7.88	51	0.7734	6.44
19	0.9395	7.83	52	0.7692	6.41
20	0.9333	7.78	53	0.7650	6.37
21	0.9271	7.72	54	0.7608	6.34
22	0.9210	7.67	55	0.7567	6.30
23	0.9150	7.62	56	0.7526	6.27
24	0.9090	7.57	57	0.7486	6.24
25	0.9032	7.53	58	0.7446	6.20
26	0.8974	7.48	59	0.7407	6.17
27	0.8917	7.43	60	0.7368	6.14
28	0.8860	7.38	61	0.7329	6.11
29	0.8805	7.34	62	0.7290	6.07
30	0.8750	7.29	63	0.7253	6.04
31	0.8695	7.24	64	0.7216	6.01
32	0.8641	7.20	65	0.7179	5.98
33	0.8588	7.15	66	0.7142	5.95
34	0.8536	7.11	67	0.7106	5.92
35	0.8484	7.07	68	0.7070	5.89
36	0.8433	7.03	69	0.7035	5.86
37	0.8383	6.98	70	0.7000	5.83
38	0.8333	6.94	75	0.6829	5.69
39	0.8284	6.90	80	0.6666	5.55
40	0.8235	6.86	85	0.6511	5.42
41	0.8187	6.82	90	0.6363	5.30
42	0.8139	6.78	95	0.6222	5.18

297—GAS PRODUCERS

The gasification of the carbon in the coal is generally assumed to occur in such a way that it first burns to carbon dioxide, CO_2. This CO_2 is then reduced to carbon monoxide, CO, by combining with more carbon. This CO forms the most important constituent of the producer gas. The reduction of CO_2 to CO is complete at a temperature of not less than about 1,850 deg. F., which latter must be generated by the preceding combustion of carbon to carbon dioxide. If the temperature in the lowest or reaction zone of the producer drops, for reasons which will be shown later, below 1,850 deg., a part of the CO_2 remains unreduced and this amount of unchanged CO_2 increases with the decrease in temperature, until at about 900 deg. F. the reduction of CO_2 to CO ceases entirely and the gas does not contain any CO at all.

The temperature in the reaction zone will influence the temperature of the escaping gases: the higher the former, the higher will be the latter. The temperature of the escaping gases could, therefore, be used as a criterion for the working of the producer, if the temperature in the reaction zone were alone responsible for it. But there may occur conditions on the top of the producer which influence the temperature of the escaping gas to a certain degree and this actually happens when part or all of the heavy hydrocarbons burn on top of the fuel bed, thus increasing the final temperature considerably. This combustion is either due to too thin a fuel bed or to the forming of channels in the fuel bed. In both cases, air will come in contact with the hydrocarbons, causing their combustion. Such a condition is not normal; yet it may happen and pass by unnoticed and, for this reason, the temperature of the gas leaving the producer should not be used for investigating the correct working of the apparatus.

The combustion of the hydrocarbons should not be confounded with the splitting-up of these constituents, which starts at about 1,300 deg. F., giving off carbon, depositing it as soot in the gas conduits.

If the gas contains a high percentage of CO_2, the producer is working cold. According to the statement made before, the reduction of CO_2 to CO is complete only at a temperature of about 1,850 deg. F. Below about 900 deg. F. no reduction takes place at all. The more, therefore, the temperature in the reaction zone approaches the higher or lower figure, the smaller or larger must be the amount of CO_2 in the gas. If we consider that a high percentage of CO_2 means a waste of fuel, because CO_2 is an inert gas, we see that the CO_2-content in the gas should be kept as low as possible.

Cold running of the producer is caused by blowing too much steam. In order to obtain a gas high in CO, the amount of steam entering the producer should be regulated carefully. If, however, the quantity of steam blown falls below a certain limit, clinkering will result, which makes difficult the removal of the ashes and may even force the producer to be shut down. The amount of steam to be used should therefore be determined and then kept as constant as possible for the coal to be gasified and also for the respective working conditions.

The objection may be made that the combustion of the heavy hydrocarbons on top of the fuel bed may influence the CO_2-content of the producer gas, since these hydrocarbons, when burning, form H_2O and CO_2. This is true. But when we consider that the total quantity of these gases, originally present in the producer gas, amounts to only a few per cent., we may easily see that the combustion of a small part of them will not alter the CO_2-content to such an extent that the latter could not be used as a criterion. It really does not matter if there be 11 or 12 per cent. CO_2 in the gas; both values show a cold producer.

A small amount of H_2 in the gas indicates that no steam is dissociated and that the gas is wet. The H_2-content gives another means for judging the steam dissociation. We have, however, always to keep in mind that we are dealing with average working conditions.

Table No. 1.

Comparison of Different Producer-gas Analysis

% Vol.	1	2	3	4	5
CO_2	9.84	5.47	4.0	4.78	7.30
O_2	.04	.08	0	.02	0
C_2H_4	.18	.58	.3	.41	.53
CO	18.28	24.29	9.8	11.32	19.20
H_2	12.90	14.62	6.4	8.60	6.37
CH_4	3.12	3.41	1.2	2.00	3.10
N_2	55.64	51.55	78.3	72.87	63.50

Comparison

A comparative burn was made a few years ago using the same coal in a direct fired and in a producer gas fired kiln. The coal analyzed:

Carbon	53.17 per cent.
Sulphur	2.0 per cent.
Water	14.65 per cent.
Hydrogen	4.47 per cent.
Oxygen plus hydrogen	16.19 per cent.
Ash	8.40 per cent.

The composition of the gas resulting from the use of this coal in the producer was

CO_2=2.2 per cent. CO=33.0 per cent.
CH_4=2.6 per cent. H =13.9 per cent.
O =0.0 per cent. N =48.3 per cent.

The length of the burn was twenty-three hours when fired by either gas or coal. At the end of six hours the temperature attained in hand firing amounted to 490 deg. C., while with gas firing it amounted to 745 deg. C. In gas firing the final temperature was reached three hours sooner than by hand firing. The burn was carried to cone 13 and three to four per cent. of carbon monoxide was carried in the gases during high fire.

The relative efficiency is shown by the number of heat units used in the two methods of firing:

Firing by hand	66,756,714 calories
Firing with producer gas	53,760,000 calories
Difference	12,996,714 calories

Nagel gives the following as the volume composition of producer gas with varying steam:

Variations in Excess of Steam

	Moderate	Great	Maximum
CO_2	5.30 per cent.	8.90 per cent.	15.00 per cent.
CO	23.50 per cent.	16.40 per cent.	11.50 per cent.
CH_4	3.30 per cent.	2.55 per cent.	1.90 per cent.
H	13.14 per cent.	18.60 per cent.	24.60 per cent.
Heat value per cu. ft.	.151 B.T.U.	.135 B.T.U.	.129 B.T.U.
Temperature	1,472 deg. F.	1,292 deg. F.	932 deg. F.

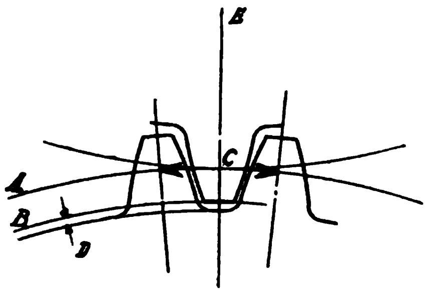
301—GEAR

Instructions for Meshing

For gears having cast teeth, the clearance equals 1/10 the pitch and for gears having cut teeth, the clearance is 1/20 the pitch.

The pitch is the distance from center to center of teeth at the pitch line. See illustration.

A—pitch line.
B—clearance line.
C—pitch.
D—clearance
E—center line thru bearings.
For cast teeth D=1/10 C.
For cut teeth D=1/20 C.



Proper Mesh of Gear Teeth

In locating the shafts so as to obtain the correct center distances for the gears, first obtain dimension C and find a piece or strip of sheet metal equal to 1/10 C for gears with cast teeth or 1/20 C for gears with cut teeth and trim it to a width which will permit it to go between the teeth freely and bear on the rim.

This strip answers for a spacer when center of tooth and corresponding space are on a center line drawn thru the two bearings and when used in this way, will insure correct mesh for the gears.

Makers of heavy machinery are often severely criticized because of improper meshing of the gears. In many cases the trouble is caused by one of two things, either the shaft has become bent, or the boxes need babbitting. To delay rebabbitting or straightening the shaft will cause excessive wear on the teeth and ultimately break them. Heavy gears are expensive enough to warrant every care being taken to protect them against such a useless strain.

Maximum Speeds

Kent gives the following as the maximum peripheral speeds in feet per minute at which the various types of gears should be operated: Ordinary cast iron gears, 1,800; helical, 2,400; mortise, 2,400; ordinary cast steel wheels, 2,600; cast steel helical, 3,000; special cast iron machine cut wheels, 3,000. To avoid great noise gears of all metal should not be run faster than 1,200 feet per minute.

The distance center to center of shafts on which are placed two gears in proper mesh is equal to one-half the sum of the pitch diameters of the two gears.

Horse Power and Working Loads of Cut Cast Iron and Cut Steel Gears

The figures in the columns headed W.L. give the working load or number of pounds of power-transmitting strain which can safely be brought on each inch width of tooth of a gear or pinion of the specified material and of the size indicated at the left of the table, when it is running at the speed listed at the top.

The figures in the columns headed H.P. give the horse powers transmitted at the speed named.

In every case multiply these figures given by the width of the working face of the gear under consideration. The feet per minute at the pitch line equals the pitch diameter in inches multiplied by the revolutions per minute and by 0.2618.

Working Loads and Horse Power of Cut Cast Iron Gears

Diametral Pitch	Arc Pitch	No. of Teeth	SPEED OF PITCH LINE—Ft. per minute											
			100		200		300		600		900		1200	
			W.L.	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.
10	.3142	12	90	27	79	47	70	63	53	.96	42	1 15	35	1 27
		20	120	36	105	63	94	85	70	1 27	56	1 53	47	1 71
		40	145	44	127	76	113	1 02	85	1 55	68	1 86	56	2 04
		60	152	46	133	.80	119	1 07	89	1 62	71	1 94	60	2 18
		130	160	49	140	.84	124	1.12	94	1 71	74	2 02	62	2 26
8	.392	12	113	34	98	.59	87	78	66	1 20	52	1 42	44	1 60
		20	150	45	130	78	116	1 04	87	1 58	70	1.91	58	2.11
		40	180	55	158	95	141	1 27	105	1 91	84	2 29	70	2.54
		60	190	.58	165	.99	148	1 33	110	2 00	88	2 40	74	2.69
		130	200	.61	174	1.04	155	1 40	115	2.09	92	2 51	77	2 80
4	785	12	225	.68	195	1.17	175	1.58	130	2 36	105	2 86	87	3 16
		20	300	91	260	1.56	230	2 08	175	3 18	140	3.82	116	4 22
		40	360	1 09	315	1.89	280	2.52	210	3.82	170	4 64	140	5.09
		60	380	1 15	330	1 98	295	2 68	220	4.00	177	4 83	147	5.35
		130	400	1.21	350	2.10	310	2.79	230	4.18	185	5 05	155	5.64
3	1.047	12	300	91	260	1 56	232	2.08	175	3 18	140	3 82	116	4 22
		20	400	1 21	350	2 10	310	2 79	232	4.22	185	5.05	155	5 64
		40	480	1 45	420	2.52	373	3.36	280	5 10	225	6.14	187	6 80
		60	503	1 52	440	2.64	391	3.52	295	5.37	235	6 42	196	7 13
		130	530	1.61	462	2 77	411	3.70	310	5.64	248	6 77	206	7 50
2	1.57	12	450	1 37	390	2 34	350	3.15	260	4.73	209	5 71	174	6 33
		20	600	1 82	520	3 12	467	4 20	350	6 37	280	7 64	232	8 44
		40	720	2 18	630	3.78	560	5 04	420	7.64	348	9.50	280	10.20
		60	760	2 30	663	3.98	592	5.33	442	8 05	355	9.70	295	10.72
		130	795	2.40	695	4.17	619	5 57	462	8 40	370	10 10	309	11 23
1 1/2	2.09	12	595	1.80	520	3.12	462	4 16	348	6.34	278	7.59	230	8.37
		20	800	2 42	700	4.20	620	5 58	466	8 47	372	10 15	310	11.28
		40	963	2 92	840	5.04	750	6.75	560	10.20	450	12.28	372	13.52
		60	1010	3 06	880	5.28	780	7.03	585	10.65	470	12.82	390	14.20
		130	1060	3.21	925	5.55	820	7.38	617	11.22	493	13.44	410	14.90

Working Loads and Horse Power of Cut Steel Gears

Diametral Pitch	Arc Pitch	No. of Teeth	SPEED OF PITCH LINE (Ft. per minute).											
			100		200		300		600		900		1200	
			W.L.	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H P.
10	3142	12	216	65	190	1.13	168	1 51	127	2 30	101	2.76	84	3.05
		20	288	.86	252	1.51	226	2.04	168	3.05	134	3 67	113	4.10
		40	348	1.06	305	1 82	272	2.45	204	3.72	163	4.46	134	4 90
		60	364	1 10	319	1.92	286	2.57	214	3.89	170	4.66	144	5.23
		130	384	1 17	336	2 02	298	2 69	226	4 10	178	4.85	149	5 42
8	392	12	271	.82	235	1.42	209	1 87	158	2.88	125	3.41	106	3.84
		20	360	1.08	312	1 87	278	2.50	209	3.80	168	4.58	139	5.06
		40	432	1.32	379	2.28	338	3.05	252	4.59	202	5.49	168	6 10
		60	456	1.39	396	2.38	355	3.19	264	4 80	211	5.76	178	6.45
		130	480	1 46	417	2 50	372	3 36	276	5.02	221	6.02	185	6.72
4	.785	12	540	1.63	467	2.81	420	3.79	312	5.67	252	6 86	209	7.58
		20	720	2.18	624	3.74	552	5.00	420	7 65	336	9 17	278	10.11
		40	863	2 62	755	4.54	672	6.05	505	9.18	408	11.13	336	12.22
		60	912	2 76	792	4.75	708	6 44	529	9.61	425	11.60	353	12.83
		130	960	2.90	840	5.04	745	6 70	553	10 03	444	12.10	372	13 53
3	1.047	12	720	2 18	624	3.74	556	5 00	420	7.65	336	9 17	278	10.11
		20	960	2.90	840	5 04	745	6 70	558	10.13	444	12.10	372	13.53
		40	1150	3.48	1008	6.05	895	8.06	673	12.25	540	14.72	449	16.30
		60	1205	3.64	1058	6.33	938	8.45	709	12.90	564	15 40	470	17.10
		130	1270	3.86	1110	6 65	987	8 87	745	13.55	595	16 23	494	18.00
2	1.57	12	1080	3.28	935	5.62	840	7.56	625	11.35	502	13.70	418	15.20
		20	1440	4.37	1250	7.48	1120	10.10	840	15.30	672	18.32	556	20.25
		40	1727	5 23	1512	9.07	1343	12.10	1008	18.35	835	22.80	672	24.45
		60	1820	5 52	1590	9.55	1420	12.80	1060	19.33	852	23.25	708	25.70
		130	1908	5 76	1670	10 00	1487	13 38	1110	20.20	888	24 20	741	26.95
1½	2.09	12	1427	4.32	1250	7.48	1110	10.00	836	15.20	667	18.20	552	20.10
		20	1920	5.80	1680	10.08	1488	13.40	1120	20.33	893	24.35	744	27.05
		40	2310	7 00	2015	12.10	1800	16.20	1345	24.50	1080	29.45	893	32.43
		60	2420	7 35	2112	12.68	1873	16.88	1403	25.60	1128	30.77	936	34.05
		130	2540	7 70	2220	13 33	1970	17 70	1483	26.95	1183	32.25	985	35.75

Formulas for the Several Parts of Gears

Let A equal the pitch diameter of the driver.

Let B equal the pitch diameter of the driven (both taken in feet or inches).

Let R equal the revolutions of the driver.

Let S equal the revolutions of the driven (both taken in the same interval of time).

Then to find one unknown quantity when the other three are known

$$A = \frac{B \times S}{R} \qquad B = \frac{A \times R}{S}$$

$$R = \frac{B \times S}{A} \qquad S = \frac{A \times R}{B}$$

Let P equal the diameter pitch

P' equal the circular pitch
D equal the outside diameter
D' equal the pitch diameter
N equal the number of teeth
S equal the addendum
f equal the clearance
t equal the thickness of tooth

$$P' = \frac{3.1416}{P} = \frac{D'}{0.3183N} = \frac{D}{0.3183\,(N+2)}$$

$$D' = N\,P'\text{x}0.3183 = \frac{N\,D}{N+2} = D - (P'\text{x}0.6366) = N\,S = \frac{N}{P} = \frac{N\,D}{N+2} = D - \frac{2}{P}$$

$$P = \frac{3.1416}{P'} = \frac{N}{D'} = \frac{N+2}{D}$$

$$D = (N + 2)\ P'\text{x}0.3183 = D' + (P'\text{x}0.6366) = S\ (N + 2) = \frac{N+2}{P}$$

$$= D' + \frac{2}{P} = \frac{N+2}{\frac{N}{D'}} = 2S + D'$$

$$N = \frac{D' \text{ x } 3.1416}{P'} = D'\,P = D\,P - 2$$

$$S = P' \text{ x } 0.3183 = \frac{1}{P}$$

$$f = P' \text{ x } 0.05 = \frac{t}{10}$$

$$t = \frac{P'}{2} = \frac{1.5708}{P}$$

Also the root $= S + f = P' \text{ x } 0.3683 = \frac{1.157}{P}$

Working depth $= 2\,S = P' \text{ x } 0.6366$

Whole depth $= 2\,S + f = P' \text{ x } 0.8666$

The diametrical pitch is the number of teeth to each inch of the pitch diameter.

The pitch diameter is the diameter measured on the pitch line.

316—GRATES AND GRATE BARS

For Horizontal Return Tubular Boilers

Diameter, Inches	Length, Feet	Square Feet of Grate Surface Required
48	14	16
54	14	18
54	16	20
60	14	22.5
60	16	25
66	16	27.5
66	18	30
72	18	33

Grate surface for burning bituminous coal is usually in the proportion of one to forty-five, fifty, fifty-five or sixty of the heating surface.

The following table gives the approximate grate area per horsepower for different rates of evaporation and combustion as compared by the following formula:

Pounds of Steam per Pound of Coal	Pounds of Coal Burned per Square Foot of Grate per Hour				
	8	10	12	15	20
10	.43	.35	.28	.23	.17
9	.48	.38	.32	.25	.19
8	.54	.43	.36	.29	.22
7	.62	.49	.41	.33	.24
6	.72	.58	.48	.38	.29

Formula for Finding Grate Area

$$S=\frac{H.P.\times 34.5}{E\times C}$$

in which
S=total grate area in square feet.
E=pounds of water evaporated per pound of coal.
C=pounds of coal burned per square foot of grate per hour.

331—HEATER, FEED WATER

It is claimed that an open heater, that is, one which has pans holding the water to be heated or some other arrangement by means of which the exhaust steam comes into direct contact with the water to be heated requires about six pounds of cold water and one pound of exhaust steam to produce seven pounds of water when heated from 50 degrees to 210 degrees F. It is further claimed that closed heaters, that is, those in which the water to be heated and the exhaust steam do not come into contact but are separated and the heat is transferred thru metal, requires about seven pounds of cold water and one and one-sixth pounds of steam for the same service. The closed heaters are usually equipped with tubes similar to a boiler.

The saving effected by heating boiler feed water by means of exhaust steam amounts to approximately one per cent. of the fuel for each eleven degrees F. rise in the temperature of the feed water.

Capacity and Dimensions of Some Closed Heaters

CAPACITY		SIZE OF OPENINGS					DIMENSIONS	
BOILER H. P	LBS. WATER PER HR.	STEAM	WATER	CONDENSATE	DRAIN	VENT	LENGTH	DIAM.
25	750	2½	1	¾		½	31¼	13
50	1500	3	2½	1		½	39	14¾
75	2250	3	2½	1		½	39	14¾
100	3000	3	2½	1		½	45	14¾
125	3750	3	2½	1		½	57	14¾
150	4500	4	3	1		½	45¾	17¾
200	6000	4	3	1		½	57¾	17¾
250	7500	4	3	1		½	69¾	17¾
300	9000	6	3½	1½	1	½	71¼	20½
350	10500	6	3½	1½	1	½	83¼	20½
400	12000	6	3½	1½	1	½	89¼	20½
500	15000	6	4	2	1¼	¾	84¾	23
600	18000	6	4	2	1¼	¾	96¾	23
700	21000	6	4	2	1¼	¾	80	25
800	24000	6	4	2	1¼	¾	92	25
900	27000	6	4	2	1¼	¾	98	25
1000	30000	8	4	2	1¼	¾	87	29¼
1200	36000	8	4	2	1¼	¾	93	29¼
1400	42000	8	4	2	1¼	¾	99	29¼
1600	48000	10	4	2	1½	1	94¼	33½
1800	54000	10	4	2	1½	1	100¼	33½
2000	60000	10	4	2	1½	1	106¼	33½
2250	67500	10	4	2	1½	1	95¾	35
2500	75000	10	4	2	1½	1	107¾	35
2750	82500	12	4	4	1½	1	98¼	40
3000	90000	12	4	4	1½	1	96¼	40
3500	105000	12	4	4	1½	1	108¼	40
4000	120000	14	6	4	2	1	105	43
4500	135000	14	6	4	2	1	123	43
5000	150000	14	6	4	2	1	114	46¼
5500	165000	14	6	4	2	1	114	46¼
6000	190000	14	6	4	2	1	126	46¼
6500	195000	14	6	4	2	1	126	46¼
7000	210000	14	6	4	2	1	138	46¼
7500	225000	14	6	4	2	1	138	46¼

These ratings are based upon heating water from 50 deg. F. to 205 deg. F. with steam at 0 lbs. (212 deg. F.).

Conversion Table

These capacities are given for 0 lbs. steam pressure. If steam at a greater pressure is used, the capacities will be increased as shown by the following table, which gives the factor to multiply the ratings at 0 lbs. steam pressure by, to arrive at the capacity with an increased steam pressure.

Conversion Table

STEAM PRESSURE	FACTOR	STEAM PRESSURE	FACTOR	STEAM PRESSURE	FACTOR	STEAM PRESSURE	FACTOR
1	1.132	11	1.896	25	2.502	75	3.683
2	1.242	12	1.950	30	2.666	80	3.762
3	1.335	13	2.001	35	2.728	85	3.841
4	1,429	14	2.051	40	2.949	90	3.917
5	1.511	15	2.097	45	3.076	100	4.059
6	1.584	16	2.143	50	3.192	110	4.195
7	1.656	17	2.188	55	3.299	120	4.316
8	1.719	18	2.232	60	3.403	130	4.438
9	1 783	19	2.274	65	3.502	140	4.615
10	1.840	20	2.314	70	3.586	150	4.649

Example:—

The boiler feed water heater that has a capacity of 1,000 h. p. can take care of 30,000 lbs. of water per hour, from 50 degrees to 205 degrees F. with steam at 0 lbs. pressure. At 5 lbs. steam pressure the factor is 1.511, therefore, 30,000 x 1.511 gives a capacity of 45,330 lbs. of water per hour from 50 degrees F. to 205 degrees F. using steam at 5 lbs. gage pressure.

336—HOLLOW BLOCK AND BRICK

The American Society for Testing Materials Has Suggested the Adoption of the Following Tentative Definitions of Terms Relating to Hollow Tile

Clay Hollow Tile.—Hollow burned clay building units with parallel cells.

Terra Cotta.—A term applying to ornamental building units of burned clay but frequently used, erroneously, to designate hollow tile.

Hollow Building Tile.—Hollow tile for use in load-bearing structural members such as floors and walls.

Load-Bearing Tile.—Tile for use in members designed to carry load.

Floor Tile.—Hollow building tile for use as a structural material in floors in conjunction with steel or reinforced concrete.

Foundation Tile.—Hollow tile used below the first floor or grade line for carrying the superstructure; also for building piers or pilasters below grade.

Side Construction Tile.—Tile designed to receive its principal stress at right angles to the direction of its cells.

End Construction Tile.—Tile designed to receive its principal stress parallel to the direction of its cells.

Back-up Tile.—Hollow building tile of suitable dimensions for use as backing in walls faced with brick or stone.

Book Tile.—Hollow tile resembling a book in shape designed to fill space between supporting members of roof or similar structures and having tongue and groove edges.

Vitrified Tile.—Tile burned to a temperature to produce vitrification but not necessarily glazed.

Salt-Glazed Tile.—Tile with a vitreous glaze on its surfaces produced by burning salt in the kiln at the temperature used in finishing the burning.

Hollow Tile Fireproofing.—Hollow tile for use in non-bearing partitions or for furring or for the protection of structural members against fire.

Partition Tile.—Hollow tile for use in building interior partitions subdividing areas into rooms or for enclosing stairways or shafts and carrying no superimposed load.

Furring Tile.—Split tile of suitable design for lining the inside of masonry walls.

Porous Tile.—Tile in which the natural porosity of the clay has been increased by the admixture of other ingredients.

Raw Materials

Shale.—A soft, fragile rock, made from clay, having an uneven, slaty structure.

Fire Clay.—A term commonly applied to buff burning clays underlying coal veins and to other buff or brown burning clays which mature at moderate or high temperatures.

Surface Clay.—A term commonly applied to soft, plastic clays which mature at comparatively low temperatures.

Designation of Dimensions

Thickness.—That dimension of a tile measured at right angles to the face of the wall or floor as it lies in the wall or floor.

Width.—That dimension of a tile measured at right angles to the direction of its thickness and cells.

Length.—That dimension of a tile measured between its cut ends.

NOTE.—In practice the first dimension given represents thickness, the second width, the third length.

Parts, Openings and Surface Features

Shells.—The outer walls of the tile.

Webs.—Partitions parallel to the cells.

Cells.—The openings in a hollow tile running parallel with its shells and webs.

Scoring.—The grooves formed in the exterior faces of the shells of the tile to increase the bond of mortar, or plaster.

Hollow Tile Specifications

The following specifications are excerpts from the tentative specifications suggested for adoption by the American Society for Testing Materials.

Physical Properties and Tests

Physical Test Requirements[1]

The average ultimate compressive strength for hollow building tile which is designed to be used with the cells vertical, and when tested in that position, shall be not less than 1,500 lb. per sq. in. of the nominal gross area of the bearing face.

The average ultimate compressive strength for hollow building tile which is designed to be used with the cells horizontal, and when tested in that position, shall be not less than 700 lb. per sq. in. of the nominal gross area of the bearing face.

Samples representing tile that is to be used for foundations or for exterior walls shall endure 30 alternate freezings and thawings without failure, as defined later.

Tile on which fire tests are made shall meet the requirements of the Standard Specifications for Fire Tests of Materials and Construction of the American Society for Testing Materials.

Table I. Data Sheet for Hollow Tile Material

Date .... Location of testing ....

Manufacturer .... At ....

Test made by .... For use in ....

Specimen Number	Sketch of Tile	Nominal Size of Tile	Position in which Tested	Color of Tile	Weight	Maximum Load	
						Lb.	Lb. per sq. in of Nominal Gross Area

Selection of Samples for Test

All tests shall be made by competent experienced operators in recognized testing laboratories.

Specimens of tile for test shall be selected by the purchaser or by a competent representative authorized by him to do this work. In all cases, the samples shall be fairly representative of the whole lot of tile from which they are selected. Full size tile shall be taken in all cases.

For the strength test five individual tile shall be selected. Five tile shall be selected for the freezing test. For the fire test, the size of the fire test specimen will govern the number of tile required.

Samples for strength test shall be selected at the factory or at the point of delivery, as specified in the sales contract. If the freezing test or the fire test, or both, is to be made, it shall be so specified at the time of placing the order; samples for these tests shall be selected at the factory, at least 45 days in advance of the time of shipment.

All tile selected for test shall be plainly and permanently marked for reference by the testing operator.

Strength Tests

Any recognized type of compression testing machine may be employed.

The speed of the moving head shall be not more than 0.05 in. per minute.

A spherical bearing block of a type in common use in testing practice shall be used. It shall be placed on the top of the test specimen.

Bearing surfaces of the test specimens and portions adjoining them which are liable to absorb water from the plastic capping which is to be applied later shall be coated with one good coat of liquid shellac and allowed to dry. They shall then be "buttered" with a plastic mortar of calcined gypsum (plaster of Paris) tempered with water to give a consistency slightly exceeding the normal. The specimen shall be given a single firm pressure upon a smooth plane surface of steel or plate glass which has been moderately oiled, and left for the capping to set. The thickness of the cap after the extruded plaster has been removed and the edges trued should be found uniform and not to exceed ⅛ in. "Patching" of caps after setting shall not be permitted and imperfect caps shall be replaced.

Tile may be tested as soon as the plaster cap has well set but not sooner than 30 minutes after the specimens have been removed from the plates.

Tile shall be tested in the position in which they are designed to be used—vertical or horizontal.

All tile shall be tested to failure.

The results of the tests shall be reported separately for each of the five individual sample tile constituting a standard test, together with the average, in the form given in Table I.

The reader is referred to the entry in the statistical section under Drain tile for outline of the freezing and thawing test as the tests are almost identical in both cases.

Tolerances

The failure of individual tile to meet the strength requirement shall not constitute cause for rejection, provided:

The average strength for the entire lot tested shall not be lower than the specified strength.

Not more than one of the five tile tested shall give a test result lower than 80 per cent. of the strength specified.

In case any lot of tile shall fail to meet the strength requirement, the shipper shall have the privilege of sorting the tile and removing those which appear to be inferior, after which new samples shall be selected, as before, except that ten shall be selected instead of five. The ten new samples shall be tested and the same tolerance observed as specified above, two out of ten tile being allowed to fall below the 80-per cent. mark instead of one out of five.

Table II. Weights, Sizes and Dimensions of Standard Load-Bearing Tile

Dimensions, Inches	Number of Cells	Scoring Depth, Inches	Scoring Spacing, Inches	Standard Weight, Pounds	Minimum Weight, Pounds
Backing-up Tile:					
4 by 5 by 12.......	1	⅛	1	9	8
8 by 5 by 12.......	2	⅛	1	15	14
8 by 5 by 12.......	3	⅛	1	17	16
Load-Bearing Wall Tile:					
3 by 12 by 12......	3	¼	2	18	17
4 by 12 by 12......	3	¼	2	20	19
6 by 12 by 12......	6	¼	2	30	28
8 by 12 by 12......	6	¼	2	36	34
10 by 12 by 12......	6	¼	2	42	40
12 by 12 by 12......	6	¼	2	48	46
Slabs..............................		optional	optional	1 lb. per 1 in. of w'h	

Failure of the samples selected after sorting, to meet the test requirement, with the tolerance given, shall constitute cause for rejection of the entire lot.

Except in those cases in which it is specified, at the time of placing the order, that the tile are to be used for foundation work, failure of individual test specimens in the freezing test shall not constitute cause for rejection, provided not more than 20 per cent. of the test specimens shall fail in this test.

Standard Sizes and Dimensions

In all tile, the net area of the cross-section taken in a plane parallel to the ends of the tile shall be not less than 45 per cent. of the gross area of the same section.

No dimension shall be more than 4 per cent. under nor 2 per cent. over the dimensions given in Table II for standard tile, or from the dimensions ordinarily recognized as standard for any other form of tile.

The weight of tile of standard size shall not be less than the minimum weights given in Table II.

Workmanship and Finish

All tile shall be free from such cracks, blisters, surface roughness and other defects as would evidently interfere with the proper setting of the tile or impair their strength or permanence.

The external surface of all tile intended for mortar or stucco shall be scored in such a manner as to give good anchorage for mortar or plaster. The standard scoring given in Table II is recommended.

Marking

All tile conforming to the design requirements of this specification shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

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[1] Further improvements are being made in these specifications, so that they are strictly tentative at this time.

Inspection and Rejection

Inspection for weight, size, sectional area, workmanship and finish shall be made by a competent inspector employed by the purchaser or builder. Such inspection shall be made at the factory or at point of delivery according to agreement between purchaser and shipper.

Individual tile shall be rejected for failure to comply with the foregoing specifications covering these points. In case more than 25 per cent. of a shipment shall fail to comply with these specifications, the purchaser may reject the entire shipment.

Selection of samples, testing and inspection shall be paid for by the purchaser.

The shipper shall afford the inspector all reasonable facilities for his work. This applies to both the selection of test samples and the visual inspection. All inspections shall be made within a reasonable time.

The inspector shall mark plainly all tile which he rejects and such rejected material shall be removed promptly by the shipper or his agent.

344—HYGROMETERS

The attached table is copied from Searle and shows the degree of humidity (the percentage of complete saturation) when the dry bulb thermometer is at the reading given in the first column of each pair, and the wet bulb is lower by the quantity D.

Dry Bulb Degrees F.	Degree of Humidity	Dry Bulb Degrees F.	Degree of Humidity	Dry Bulb Degrees F.	Degree of Humidity
D=2 D	egrees	D=5 d	egrees	D=10 d	egrees
30	69	42	63	60	50
31	72	44	65	62	50
32	75	46	67	64	51
33	78	D=8 d	egrees	66	52
34	79	46	51	68	52
D=3 d	egrees	48	52	70	53
35	72	50	53	72	54
36	74	52	54	74	55
37	75	54	55	76	55
D=5 d	egrees	56	56	78	56
38	62	58	57	80	56
39	63	60	58	82	57
40	63			84	57

386—KILN, DOWN-DRAFT, DESIGN AND CONSTRUCTION

To Find Size of Flues in Down-draft Kilns

One of the most important points to consider in the design and construction of down-draft kilns is the size of the flues, and this is most important in the watersmoking period of the burn. Clay products that have been dried thoroly, still contain about 300 pounds of water per ton of ware. This water is removed during the watersmoking period of the burn. Every pound of water produces approximately 27 cubic feet of steam. Therefore every ton of clay ware produces about 8,100 cubic feet of steam. A kiln therefore which contains 60,000 brick each weighing 6 pounds, making a total of 180 tons, produces 1,458,000 cubic feet of steam or moisture vapor. The flue system must carry away this amount of steam and in addition must carry the gases resulting from the combustion of the fuel. If the ware will permit of drying in 2 days the steam alone will amount to 30,375 cubic feet per hour. Suppose that the smallest area in the flue and stack system is 18 square feet.

If the moisture or steam escaping from the kiln stack could be maintained at a temperature of 212 degrees or more, this hot moisture or steam would escape without any assistance from air to carry it, but in actual practice air must be used as the medium or vehicle to remove the moisture. Suppose that 100 cubic feet of air in traveling thru the kiln takes up 0.4 pound of moisture. That equals about 11 cubic feet of moisture. 1,458,000÷0.11 =13,254,600 which is the amount of cubic feet of air that is necessary as the carrier of the cubic feet of moisture or steam. The total gas to be provided for, however, is less than the sum of the vapor and air as shown by these figures. To be conservative we will use the figures 13,254,600 as the cu. ft. of gas to be provided for. This equals 276,138 cubic feet per hour if the watersmoking is completed in two days.

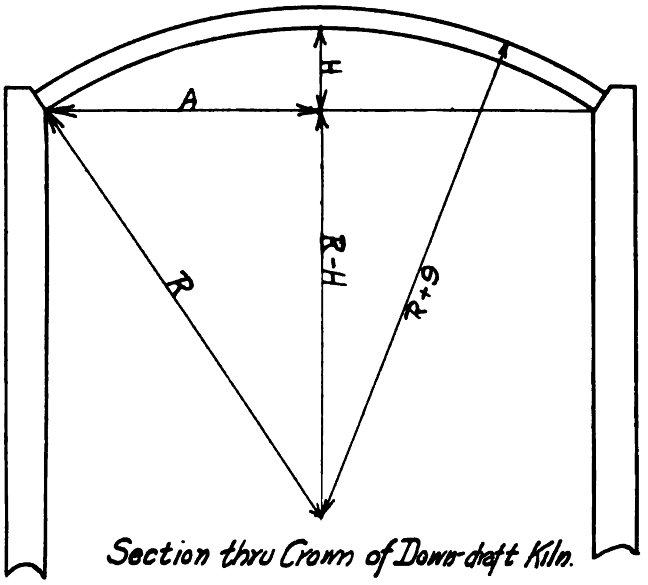
Approximately 18 pounds of air are required for the combustion of one pound of coal. Since air weighs about .07 pound per cubic foot at ordinary temperature, one pound of coal requires approximately 257 cubic feet of air. Suppose that the kiln uses about 1,000 pounds of coal per hour at the height of the watersmoking period. Suppose that each pound of coal requires 257 cubic feet of air and that the products of combustion will occupy the same space. That adds 257,000 cubic feet to 276,138 making 533,138 cubic feet to be taken care of by the stack per hour. This makes the lineal travel thru a flue with an area of 18 square feet equal 29,619 feet per hour or 494 feet per minute.

This imaginary case is shown to impress upon the reader the necessity of ample flue and stack capacity. In many cases the flue system of a kiln is damp, thereby causing additional steam which must be taken care of.

To Find Number of Brick in Down-draft Kiln Crown

The following figures are made on a fire brick crown as that is advisable in every case.

Most of the crowns of round down draft kilns are a part of a true sphere. This is true when one radius is used for the entire crown.



Section thru Crown of Down-draft Kiln.

To find the surface of the inside of a kiln crown multiply twice the radius of the crown by the rise of the crown and this by 3.14159.

To find the radius for a crown from the diameter of the kiln and the rise of the crown,

$$2R = \frac{A^2}{H} + H$$

in which R=the radius of the crown
A=one-half of the diameter of the kiln
H=the rise of the crown or the distance from the spring line to the highest part of the inside of the crown.

Take a kiln of 30 foot diameter and a rise of eight feet. It is necessary first to determine the radius. From the formula this is:

$$2R = \frac{15^2}{8} + 8 = 36.125 \text{ feet}$$

$$R = 18.0625 \text{ feet}$$

Then the inside area of the crown equals 2x18.0625x8x3.14159=907.91951 square feet.

The radius of the outside of the crown is usually nine inches larger than the inside radius. To determine the area of the outside of the crown use this proportion:

$$\frac{18.0625 \text{ (inside radius)}}{18.8125 \text{ (outside radius)}} = \frac{907.91951}{\text{Area of outside surface of crown}}$$

From this we determine that the outside surface equals 945.61928 square feet. A standard brick measures 2½x 4½ inches on the outside end. This equals 11¼ square inches or 12.8 brick per square foot. 945.6x12.8 equals 12104 which is the total number of brick necessary to build the crown.

To determine the number of wedge brick necessary we determine the number of wedge brick in one circle across the kiln. By referring to the table of circular arcs we find that the span 30 feet divided into the height 8 feet equals .267, and that the figure in the column of lengths corresponding thereto is 1.18040. This latter figure multiplied by the span 30 feet equals 35.412 which is the length of the arc across the center of the kiln. The corresponding arc for the outside of the crown is in direct proportion to the difference in the two radii.

$$\frac{18.0625}{18.8125} = \frac{35.4}{\text{length of arc for outside of crown}}$$

From this we determine that the length of the arc is 36.87 feet or 442.44 inches. This last figure divided by 2½ inches, the thickness of one brick, gives 177 brick as the number in one arc across the kiln.

Again 36.87 feet minus 35.4 feet equals 1.47 feet or 17.5 inches. A number one wedge brick measures ⅝ inch less in thickness than a square or straight brick on the small end. 17.5 inches divided by 0.625 equals 28 brick in every circle or 28 out of every 177 brick in the crown that must be number one wedge. This makes the requirements of this crown 1,934 number one wedge and 10,200 nine-inch straights or squares.

To check this estimate: The difference in the areas of the inside and outside surfaces equals 37.69977 square feet. A brick 2½x4½ has 11.25 square inches and the small end of a number wedge brick has 1⅞x4½ or 8.4375 square inches. The difference between these areas is 2.8125 square inches or 0.01953 square feet. 37.69977 divided by 0.01953 equals 1930 brick, which means that 1930 brick in the crown must be wedges and the rest straight or square brick. The two methods of figuring are a little at variance on account of the large decimals involved.

To Find Brick in Crown of Square Down-draft

Consider a square kiln 20 feet wide, 45 feet long and a rise of six feet to the crown.

In figuring the number of brick in the crown of a square down-draft kiln, or in the arch of any flue use the table attached for the length of circular arcs. To use this table divide the rise of the crown by the span or the width of the kiln. In the column of heights find the number closest to this quotient. Take the number in the column of lengths corresponding to this quotient, and multiply by the span or width of kiln. This will give the distance across the inside of the crown as 24.5 feet or 294 inches. We must now find the radius. In the sketch $2R = \frac{A^2}{H} + H$.

Substituting the values given we have $2R = \frac{100}{6} + 6$.

Therefore R = 11 feet 4 inches or 136 inches and R + 9 = 145 inches.

To find the length of the circular arc for the outside of the crown we use the formula:

$$\frac{294}{136} = \frac{\text{Length of outside arc}}{145}$$

From this proportion we find that the length of the outside arc is 313.4 inches.

313.4 divided by 2½ inches, the thickness of one brick on the outside of the kiln crown, equals 126 brick. 126 multiplied by 120 which is the number of brick in the length of the kiln (arrived at by dividing 4½ inches, the width of one brick, into 12 and multiplying by 45, the length of the kiln) equals 15,120 brick total in the crown. 313.4 — 294 equals 19.4 which is the difference that must be made up by the use of wedge brick. The standard number one wedge brick measures (on the small end) 1⅞ inches or ⅝ of an inch less than a square or nine inch straight. Divide 19.4 by ⅝ and we find the quotient to be 31 which means that 31 out of the 126 brick across the kiln must be wedge brick. Therefore 31 are number one wedge brick and 95 nine-inch straights.

31x120 for the length of the kiln equals. 3,720
95x120 for the length of the kiln equals. 11,400

Total (same as found above).......15,120

Finding Length of Arc of Crown

Knowing its chord and height, divide the height by the chord. Find in the column of heights the number equal to this quotient. Take out the corresponding number from the column of lengths. Multiply this last number by the length of the given chord.

TABLE OF CIRCULAR ARCS.

No errors.

H'ghts.	Lengths.	H'ghts.	Lengths.	H'ghts.	Lengths.	H'ghts.	Lengths.	H'ghts.	Lengths.
.001	1.00002	.076	1.01533	.151	1.05973	.226	1.13108	.301	1.22636
.002	1.00002	.077	1.01573	.152	1.06051	.227	1.13219	.302	1.22778
.003	1.00003	.078	1.01614	.153	1.06130	.228	1.13331	.303	1.22920
.004	1.00004	.079	1.01656	.154	1.06209	.229	1.13444	.304	1.23063
.005	1.00007	.080	1.01698	.155	1.06288	.230	1.13557	.305	1.23206
.006	1.00010	.081	1.01741	.156	1.06368	.231	1.13671	.306	1.23349
.007	1.00013	.082	1.01784	.157	1.06449	.232	1.13785	.307	1.23492
.008	1.00017	.083	1.01828	.158	1.06530	.233	1.13900	.308	1.23636
.009	1.00022	.084	1.01872	.159	1.06611	.234	1.14015	.309	1.23781
.010	1.00027	.085	1.01916	.160	1.06693	.235	1.14131	.310	1.23926
.011	1.00032	.086	1.01961	.161	1.06775	.236	1.14247	.311	1.24070
.012	1.00038	.087	1.02006	.162	1.06858	.237	1.14363	.312	1.24216
.013	1.00045	.088	1.02052	.163	1.06941	.238	1.14480	.313	1.24361
.014	1.00053	.089	1.02098	.164	1.07025	.239	1.14597	.314	1.24507
.015	1.00061	.090	1.02146	.165	1.07109	.240	1.14714	.315	1.24654
.016	1.00069	.091	1.02192	.166	1.07194	.241	1.14832	.316	1.24801
.017	1.00078	.092	1.02240	.167	1.07279	.242	1.14951	.317	1.24948
.018	1.00087	.093	1.02289	.168	1.07365	.243	1.15070	.318	1.25095
.019	1.00097	.094	1.02339	.169	1.07451	.244	1.15189	.319	1.25243
.020	1.00107	.095	1.02389	.170	1.07537	.245	1.15308	.320	1.25391
.021	1.00117	.096	1.02440	.171	1.07624	.246	1.15428	.321	1.25540
.022	1.00128	.097	1.02491	.172	1.07711	.247	1.15549	.322	1.25689
.023	1.00140	.098	1.02542	.173	1.07799	.248	1.15670	.323	1.25838
.024	1.00153	.099	1.02593	.174	1.07888	.249	1.15791	.324	1.25988
.025	1.00167	.100	1.02646	.175	1.07977	.250	1.15912	.325	1.26138
.026	1.00182	.101	1.02698	.176	1.08066	.251	1.16034	.326	1.26288
.027	1.00196	.102	1.02752	.177	1.08156	.252	1.16156	.327	1.26437
.028	1.00210	.103	1.02806	.178	1.08246	.253	1.16279	.328	1.26588
.029	1.00225	.104	1.02860	.179	1.08337	.254	1.16402	.329	1.26740
.030	1.00240	.105	1.02914	.180	1.08428	.255	1.16526	.330	1.26892
.031	1.00256	.106	1.02970	.181	1.08519	.256	1.16650	.331	1.27044
.032	1.00272	.107	1.03026	.182	1.08611	.257	1.16774	.332	1.27196
.033	1.00289	.108	1.03082	.183	1.08704	.258	1.16899	.333	1.27349
.034	1.00307	.109	1.03139	.184	1.08797	.259	1.17024	.334	1.27502
.035	1.00327	.110	1.03196	.185	1.08890	.260	1.17150	.335	1.27656
.036	1.00345	.111	1.03254	.186	1.08984	.261	1.17276	.336	1.27810
.037	1.00364	.112	1.03312	.187	1.09079	.262	1.17403	.337	1.27964
.038	1.00384	.113	1.03371	.188	1.09174	.263	1.17530	.338	1.28118
.039	1.00405	.114	1.03430	.189	1.09269	.264	1.17657	.339	1.28273
.040	1.00426	.115	1.03490	.190	1.09365	.265	1.17784	.340	1.28428
.041	1.00447	.116	1.03551	.191	1.09461	.266	1.17912	.341	1.28583
.042	1.00469	.117	1.03611	.192	1.09557	.267	1.18040	.342	1.28739
.043	1.00492	.118	1.03672	.193	1.09654	.268	1.18169	.343	1.28895
.044	1.00515	.119	1.03734	.194	1.09752	.269	1.18299	.344	1.29052
.045	1.00539	.120	1.03797	.195	1.09850	.270	1.18429	.345	1.29209
.046	1.00563	.121	1.03860	.196	1.09949	.271	1.18559	.346	1.29366
.047	1.00587	.122	1.03923	.197	1.10048	.272	1.18689	.347	1.29523
.048	1.00612	.123	1.03987	.198	1.10147	.273	1.18820	.348	1.29681
.049	1.00638	.124	1.04051	.199	1.10247	.274	1.18951	.349	1.29839
.050	1.00665	.125	1.04116	.200	1.10347	.275	1.19082	.350	1.29997
.051	1.00692	.126	1.04181	.201	1.10447	.276	1.19214	.351	1.30156
.052	1.00720	.127	1.04247	.202	1.10548	.277	1.19346	.352	1.30315
.053	1.00748	.128	1.04313	.203	1.10650	.278	1.19479	.353	1.30474
.054	1.00776	.129	1.04380	.204	1.10752	.279	1.19612	.354	1.30634
.055	1.00805	.130	1.04447	.205	1.10855	.280	1.19746	.355	1.30794
.056	1.00834	.131	1.04515	.206	1.10958	.281	1.19880	.356	1.30954
.057	1.00864	.132	1.04584	.207	1.11062	.282	1.20014	.357	1.31115
.058	1.00895	.133	1.04652	.208	1.11165	.283	1.20149	.358	1.31276
.059	1.00926	.134	1.04722	.209	1.11269	.284	1.20284	.359	1.31437
.060	1.00957	.135	1.04792	.210	1.11374	.285	1.20419	.360	1.31599
.061	1.00989	.136	1.04862	.211	1.11479	.286	1.20555	.361	1.31761
.062	1.01021	.137	1.04932	.212	1.11584	.287	1.20691	.362	1.31923
.063	1.01054	.138	1.05003	.213	1.11690	.288	1.20827	.363	1.32086
.064	1.01088	.139	1.05075	.214	1.11796	.289	1.20964	.364	1.32249
.065	1.01123	.140	1.05147	.215	1.11904	.290	1.21102	.365	1.32413
.066	1.01158	.141	1.05220	.216	1.12011	.291	1.21239	.366	1.32577
.067	1.01193	.142	1.05293	.217	1.12118	.292	1.21377	.367	1.32741
.068	1.01228	.143	1.05367	.218	1.12225	.293	1.21515	.368	1.32905
.069	1.01264	.144	1.05441	.219	1.12334	.294	1.21654	.369	1.33069
.070	1.01302	.145	1.05516	.220	1.12444	.295	1.21794	.370	1.33234
.071	1.01338	.146	1.05591	.221	1.12554	.296	1.21933	.371	1.33399
.072	1.01376	.147	1.05667	.222	1.12664	.297	1.22073	.372	1.33564
.073	1.01414	.148	1.05743	.223	1.12774	.298	1.22213	.373	1.33730
.074	1.01453	.149	1.05819	.224	1.12885	.299	1.22354	.374	1.33896
.075	1.01493	.150	1.05896	.225	1.12997	.300	1.22495	.375	1.34063

392—KILN INSULATION

The B. t. u. transmitted per square foot of surface per degree difference in temperature thru brick work is as follows:

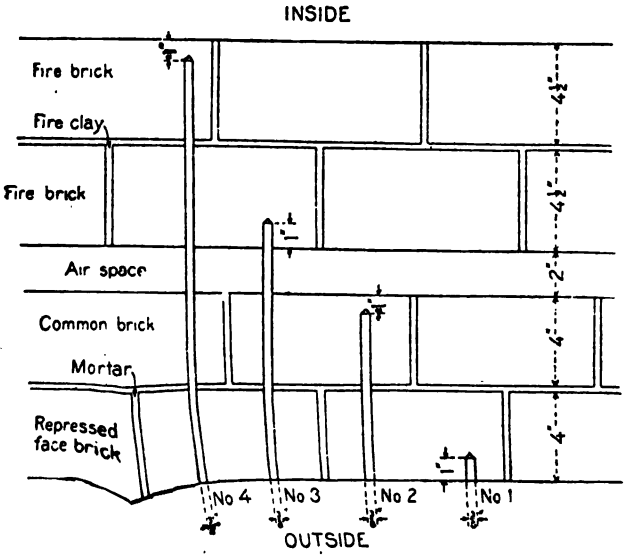


Fig 4 Construction of Furnace Walls and Position of Thermo-couples.

4 inches	0.68
8 inches	0.46
12 inches	0.33
16 inches	0.27
20 inches	0.23
24 inches	0.20
28 inches	0.18
32 inches	0.16
36 inches	0.15

The four attached illustrations are taken from a bulletin of the Bureau of Mines and show the methods and results of the test to determine the radiation of heat thru brickwork. The inside of the furnace was maintained at 2,000 degrees F. until the various readings were constant.

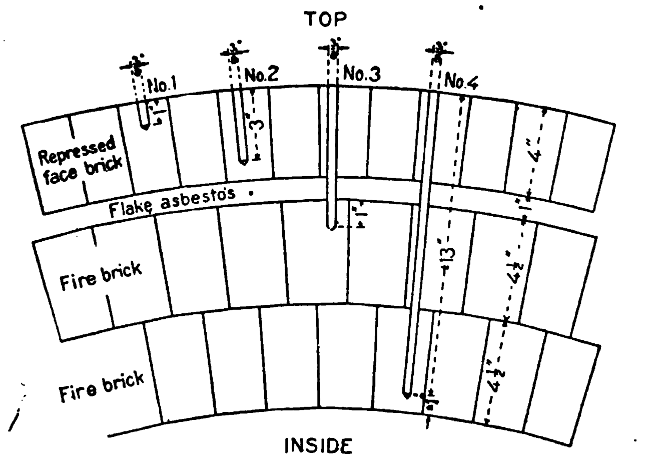


Fig. 2. Construction of Furnace Roof and Position of Thermocouples.

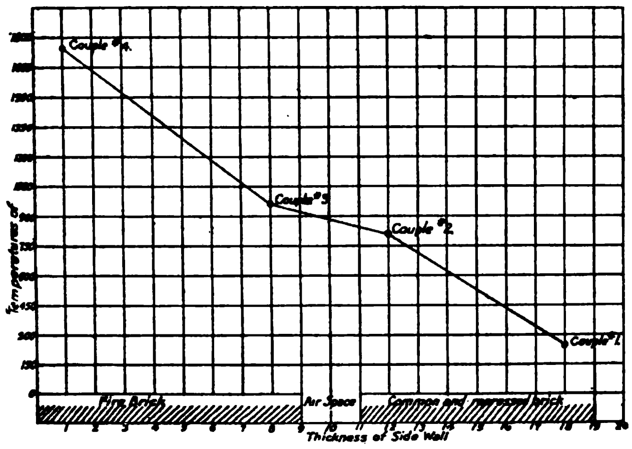


Fig. 3. Temperature in Side Walls.

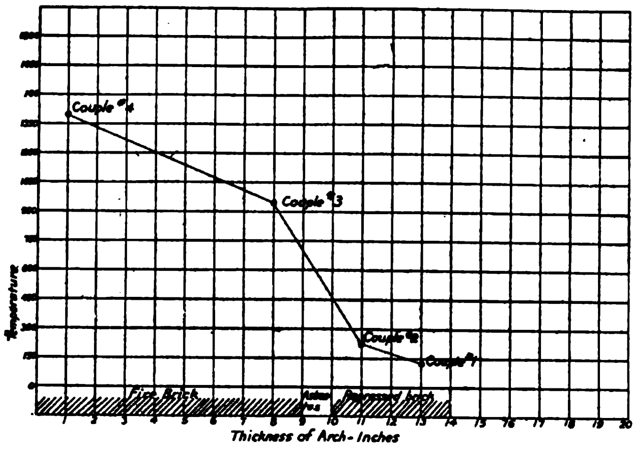


Fig. 4. Temperatures in Arch.

410—LOCOMOTIVES, ELECTRIC STORAGE BATTERY AND TROLLEY

Haulage Capacity of Electric Locomotives Equipped with Cast Chilled Wheels

Table A gives the draw-bar pull in pounds and the haulage capacity in tons for a given weight of locomotive on various grades, when equipped with chilled cast iron wheels. A coefficient of friction of 30 pounds per ton has been assumed on level track, and 20 pounds per ton for each per cent. of grade.

Table A

GRADE	LEVEL		1%		2%		3%		4%		5%	
Loco. Wt. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons
4	1600	53	1520	31	1440	20	1360	15	1280	12	1200	9
6	2400	80	2280	45	2160	31	2040	23	1922	17	1800	14
8	3200	107	3040	61	2880	41	2720	30	2560	23	2400	18
10	4000	133	3800	76	3600	51	3400	38	3200	29	3000	23
13	5200	174	4940	98	4680	67	4420	49	4160	38	3900	30
15	6000	200	5700	114	5400	77	5100	57	4800	43	4500	35
20	8000	267	7600	152	7200	103	6800	75	6400	58	6000	46
25	10000	330	9500	190	9000	118	8500	95	8000	72	7500	58
30	12000	400	11400	227	10800	156	10200	113	9600	87	9000	70

GRADE	LEVEL		6%		7%		8%		9%		10%	
Loco. Wt. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons
4	1600	53	1120	7	1040	6	960	5	880	4	800	3
6	2400	80	1680	11	1560	9	1440	7	1320	6	1200	5
8	3200	107	2240	15	2080	12	1920	10	1760	8	1600	7
10	4000	133	2800	19	2600	15	2400	13	2200	10	2000	9
13	5200	174	3640	24	3380	20	3120	16	2860	14	2600	11
15	6000	200	4200	28	3900	23	3600	19	3300	16	3000	13
20	8000	267	5600	37	5200	31	4800	27	4400	21	4000	17
25	10000	330	7000	46	6500	38	6000	32	5500	26	5000	22
30	12000	400	8400	56	7800	46	7200	38	6600	32	6000	26

Haulage Capacity of Electric Mine Locomotives Equipped with Steel Tired Wheels

Table B gives the draw-bar pull in pounds and the haulage capacity in tons for a given weight of locomotive

Table B

GRADE	LEVEL		1%		2%		3%		4%		5%	
Loco. Wt. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons
4	2000	70	1920	39	1840	26	1760	20	1680	15	1600	12
6	3000	100	2880	58	2760	39	2640	29	2520	23	2400	18
8	4000	133	3840	77	3680	53	3520	39	3360	30	3200	25
10	5000	167	4800	96	4600	66	4400	49	4200	38	4000	31
13	6500	216	6240	126	5980	85	5720	63	5460	50	5200	40
15	7500	250	7200	144	6900	99	6600	73	6300	57	6000	46
20	10000	333	9600	192	9200	132	8000	98	8400	76	8000	62
25	12500	416	12000	240	11500	164	11000	122	10500	96	10000	77
30	15000	500	14400	287	13800	197	13200	146	12600	114	12000	92

GRADE	LEVEL		6%		7%		8%		9%		10%	
Loco. Wt. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulage Cap. Tons	Draw Bar Pull Lbs.	Haulaeg Cap. Tons
4	2000	70	1520	10	1440	8	1360	7	1280	6	1200	5
6	3000	100	2280	15	2160	13	2040	11	1920	9	1800	8
8	4000	133	3040	20	2880	17	2720	14	2560	12	2400	10
10	5000	167	3800	26	3600	21	3400	18	3200	15	3000	13
13	6500	216	4940	33	4680	27	4420	23	4160	20	3900	17
15	7500	250	5700	38	5400	32	5100	27	4800	23	4500	19
20	10000	333	7600	51	7200	42	6800	36	6400	30	6000	26
25	12500	416	9500	64	9000	53	8500	45	8000	38	7500	32
30	15000	500	11400	76	10800	63	10200	53	9600	46	9000	39

on various grades, when equipped with steel tired wheels. A coefficient of friction of 30 pounds per ton has been assumed on level tracks, and 20 pounds per ton for each per cent. of grade.

Courtesy Jeffrey Mfg. Co.

430—MOTOR, ELECTRIC

Table of Electrical Horse Powers

Formula: $\frac{\text{Volts} \times \text{Amperes}}{746} = \text{H.P.}$, or 1 volt ampere = .0013405 H.P.

Read amperes at top and volts at side or *vice versa.*

Amperes or Volts.	Volts or Amperes.												
	1	10	20	30	40	50	60	70	80	90	100	110	120
1	.00134	.0134	.0268	.0402	.0536	.0670	.0804	.0938	.1072	.1206	.1341	.1475	.1609
2	.00268	.0268	.0536	.0804	.1072	.1341	.1609	.1877	.2145	.2413	.2681	.2949	.3217
3	.00402	.0402	.0804	.1206	.1609	.2011	.2413	.2815	.3217	.3619	.4022	.4424	.4826
4	.00536	.0536	.1072	.1609	.2145	.2681	.3217	.3753	.4290	.4826	.5362	.5898	.6434
5	.00670	.0670	.1341	.2011	.2681	.3351	.4022	.4692	.5362	.6032	.6703	.7373	.8043
6	.00804	.0804	.1609	.2413	.3217	.4022	.4826	.5630	.6434	.7239	.8043	.8847	.9652
7	.00938	.0938	.1877	.2815	.3753	.4692	.5630	.6568	.7507	.8445	.9384	1.032	1.126
8	.01072	.1072	.2145	.3217	.4290	.5362	.6434	.7507	.8579	.9652	1.072	1.180	1.287
9	.01206	.1206	.2413	.3619	.4826	.6032	.7239	.8445	.9652	1.086	1.206	1.327	1.448
10	.01341	.1341	.2681	.4022	.5362	.6703	.8043	.9383	1.072	1.206	1.341	1.475	1.609
11	.01475	.1475	.2949	.4424	.5898	.7373	.8847	1.032	1.180	1.327	1.475	1.622	1.769
12	.01609	.1609	.3217	.4826	.6434	.8043	.9652	1.126	1.287	1.448	1.609	1.769	1.930
13	.01743	.1743	.3485	.5228	.6970	.8713	1.046	1.220	1.394	1.568	1.743	1.917	2.091
14	.01877	.1877	.3753	.5630	.7507	.9384	1.126	1.314	1.501	1.689	1.877	2.064	2.252
15	.02011	.2011	.4022	.6032	.8043	1.005	1.206	1.408	1.609	1.810	2.011	2.212	2.413
16	.02145	.2145	.4290	.6434	.8579	1.072	1.287	1.501	1.716	1.930	2.145	2.359	2.574
17	.02279	.2279	.4558	.6837	.9115	1.139	1.367	1.595	1.823	2.051	2.279	2.507	2.735
18	.02413	.2413	.4826	.7239	.9652	1.206	1.448	1.689	1.930	2.172	2.413	2.654	2.895
19	.02547	.2547	.5094	.7641	1.019	1.273	1.528	1.783	2.037	2.292	2.547	2.801	3.056
20	.02681	.2681	.5362	.8043	1.072	1.340	1.609	1.877	2.145	2.413	2.681	2.949	3.217

Values for larger items can be obtained by multiplying the values shown in this table.

462—PIPE AND PIPE FITTINGS

To find the area of a required pipe, the volume and velocity of water being given.

Multiply the number of cubic feet of water by 144 and divide the product by the velocity in feet per minute. The answer which is the area will enable the size to be determined from the table of pipe sizes.

A pipe one yard long holds as many pounds of water as the square of its diameter in inches. Thus a six-inch pipe holds 36 pounds of water in each yard of its length.

Velocity of Flow of Water in Pipes

Velocity of flow in flat countries is between 120 and 240 feet per minute, and the average is about 180 feet per minute. The head required to maintain the latter velocity thru a length of clean cast iron pipe is equal to

$$\frac{\text{Length of pipe in feet}}{25 \times \text{diameter of pipe in inches}}$$

and the discharge in cubic feet per minute is very nearly equal to the square of the diameter of the pipe in inches. The error with this calculation is less than two per cent. in excess.

For example find the loss in head or the head required to maintain a velocity of 180 feet per minute thruout a 12-inch pipe 400 feet long.

$$\text{Loss of head} = \frac{400}{25 \times 12} = 133 \text{ feet}$$

Thickness of Pipe for Various Bends

The thickness of the wall of the pipe in a bend should be determined by the pressure under which the bend is to be operated and the diameter of the pipe. The thicknesses given in the table below are the lightest recommended and carry a sufficient safety factor, taking into consideration the scaling of pipe in the bending fire and thinning of wall due to stretching during the bending process.

Up to 125 Pounds Working Pressure

RADIUS	PIPE SIZE	PIPE
4 to 5 diameters........	7 in. and smaller......	Extra strong.
	8 in. and larger.......	½ in. thick.
Over 5 diameters.......	7 in. and smaller......	Full weight.
	8 in..................	28.55 lbs. per ft.
	10 in.................	40.48 lbs. per ft.
	12 in.................	49.56 lbs. per ft.
	14 in. to 16 in., incl....	5/16 in. thick.
	18 in. to 22 in., incl....	3/8 in. thick.
	24 in. to 30 in., incl....	7/16 in. thick.

APPROXIMATE LENGTH OF PIPE IN QUARTER BENDS EXCLUSIVE OF TANGENTS

Radius Inches	Length Inches	Radius Inches	Length Inches	Radius Inches	Length Inches	Radius Inches	Length Inches
4	6¼	42	66	80	125¾	118	185¼
5	7¾	43	67½	81	127¼	119	187
6	9½	44	69¼	82	128¾	120	188½
7	11	45	70¾	83	130½	121	190
8	12½	46	72¼	84	132	122	191½
9	14¼	47	73¾	85	133½	123	193¼
10	15¾	48	75½	86	135	124	194¾
11	17¼	49	77	87	136¾	125	196¼
12	18¾	50	78½	88	138¼	126	198
13	20½	51	80	89	139¾	127	199½
14	22	52	81¾	90	141¼	128	201
15	23½	53	83¼	91	143	129	202¾
16	25¼	54	84¾	92	144½	130	204¼
17	26¾	55	86½	93	146	131	205¾
18	28¼	56	87½	94	147¾	132	207¼
19	29¾	57	89½	95	149¼	133	209
20	31½	58	91	96	150¾	134	210½
21	33	59	92¾	97	152¼	135	212
22	34½	60	94¼	98	154	136	213¾
23	36¼	61	95¾	99	155½	137	215¼
24	37¾	62	97½	100	157	138	216¾
25	39¼	63	99	101	158¾	139	218¼
26	40¾	64	100½	102	160¼	140	220
27	42½	65	102	103	161¾	141	221½
28	44	66	103¾	104	163¼	142	223
29	45½	67	105¼	105	165	143	224¾
30	47¼	68	106¾	106	166½	144	226¼
31	48¾	69	108½	107	168	145	227¾
32	50¼	70	110	108	169¾	146	229¼
33	51¾	71	111½	109	171¼	147	231
34	53½	72	113	110	172¾	148	232½
35	55	73	114½	111	174¼	149	234
36	56½	74	116¼	112	176	150	235½
37	58¼	75	117¾	113	177½	151	237¼
38	59¾	76	119½	114	179	152	238¾
39	61¼	77	121	115	180¾	153	240¼
40	62¾	78	122½	116	182¼	154	242
41	64½	79	124	117	183¾	155	243½

125 Pounds to 250 Pounds Working Pressure

4 to 5 and 6 diameters..	7 in. and smaller......	Extra strong.
	8 in. and larger.......	½ in. thick.
Over 6 diameters.......	7 in. and smaller......	Full weight.
	8 in..................	28.55 lbs. per ft.
	10 in.................	40.48 lbs. per ft.
	12 in.................	49.56 lbs. per ft.
	14 in. to 16 in., incl....	3/8 in. thick.
	18 in. to 22 in., incl....	7/16 in. thick.
	24 in. to 30 in., incl....	½ in. thick.

250 Pounds to 350 Pounds Working Pressure

4 diameters and over....	7 in. and smaller......	Extra strong.
	8 in. and larger.......	½ in. thick.

Courtesy Crane Co.

Flow of Steam in Pipes

To determine the velocity of steam in feet per minute thru a pipe, the quantity, pressure and area being known,

V equals velocity in feet per minute.
A equals pounds of steam per hour.
B equals volume in cubic feet of 1 lb. at given pressure.
C equals area of pipe in square inches.
1728 equals cubic inches in a cubic foot.
60 equals minutes in an hour.
12 equals inches in a foot.

Then V equals $\frac{A \times B \times 1728}{60 \times C \times 12}$ equals $\frac{A \times B \times 2.4}{C}$

Or A equals $\frac{C \times V}{B \times 2.4}$

Or B equals $\frac{C \times V}{A \times 2.4}$

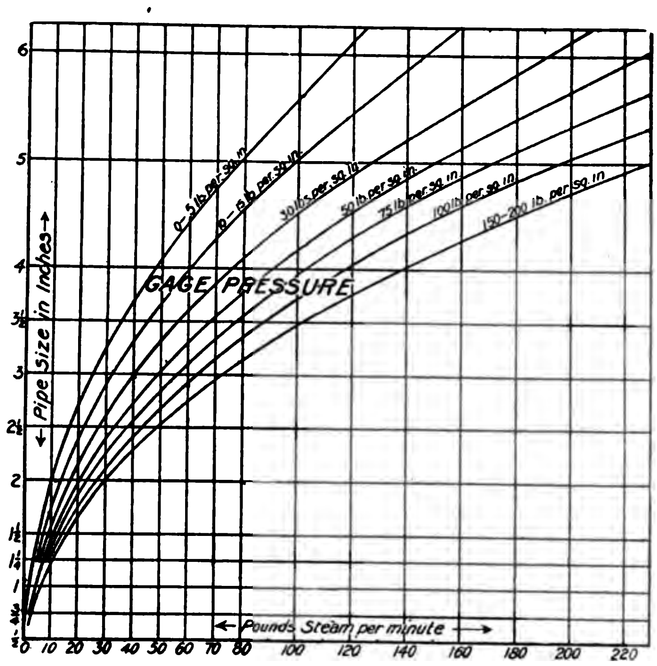
Or C equals $\frac{A \times B \times 2.4}{V}$

Loss of Pressure

The above formula does not consider the probable drop, or loss of pressure which is dependent upon the velocity of flow, length of line, number of turns in fittings or valves, and the covering of the pipe. In every steam line there must be a difference in pressure between the inlet and outlet or there could be no flow, and this difference is increased by friction and radiation.

In power plant work a steam velocity of 4,000 to 6,000 feet per minute may be employed without excessive loss, in properly covered pipes 6 inches diameter or larger. For smaller pipe use a lower velocity.

To Find the Correct Pipe Size for any Steam Job



We are indebted to the Metal Worker, Plumber and Steam Fitter for this chart, based on the well-known Babcock Formula. To find the correct pipe size for any job, all you need is the gage-pressure and the number of pounds of steam required per minute. Thus, a 150 H. P. engine, operating at 100 lbs. pressure, will require about 100 lbs. steam per minute. Following up these lines on the chart, it will be found that 4-inch pipe is required.

Where the lines cross at an intermediate point, the next size larger is the correct pipe to use. No further calculation is required.

American Briggs Standard for Taper and Straight Pipe Threads and Lock-Nut Threads

Adopted by the committee of manufacturers of standardization of fittings and valves and the American Society of American Engineers, Sept. 17, 1913.

Standard Pipe Thread Dimensions

Size	A	B	C	D	E	F	G	Depth of Thread	Threads per Inch
⅛	36350	37475	38400	39632	2638	180	405	02962	27
¼	47739	48989	50378	50725	4018	200	540	04444	18
⅜	61201	62701	64090	64437	4078	240	675	04444	18
½	75843	77843	79628	80075	5337	320	840	05714	14
¾	96768	98886	1 00671	1 01118	5457	339	1 050	05714	14
1	1 21363	1 23863	1 26036	1 26580	6828	400	1 315	06956	11½
1¼	1 55713	1 58338	1 60511	1 61055	7068	420	1 660	06956	11½
1½	1 79609	1 82234	1 84407	1 84951	7235	420	1 900	06956	11½
2	2 26902	2 29627	2 31801	2 32344	7565	436	2 375	06956	11½
2½	2 71954	2 76216	2 79341	2 80122	1 1375	682	2 875	100	8
3	3 34063	3 38850	3 41975	3 42756	1 2000	766	3 500	100	8
3½	3 83750	3 88881	3 92006	3 92787	1 2500	821	4 000	100	8
4	4 33438	4 38713	4 41838	4 42619	1 3000	844	4 500	100	8
4½	4 83125	4 88593	4 91718	4 92499	1 3500	875	5 000	100	8
5	5 39074	5 44930	5 48055	5 48836	1 4063	937	5 563	100	8
6	6 44610	6 50597	6 53722	6 54503	1 5125	958	6 625	100	8
7	7 43985	7 50235	7 53360	7 54141	1 6125	1 000	7 625	100	8
8	8.43360	8 50003	8 53128	8 53909	1 7125	1 063	8 625	100	8
9	9 42735	9 49797	9 52922	9 53703	1 8125	1 130	9 625	100	8
10	10 54532	10 62094	10 65219	10 66000	1 9250	1 21	10 750	100	8
11	11 53907	11 61938	11 65063	11 65844	2 0250	1 285	11 750	100	8
12	12 53282	12 61782	12 64007	12 65688	2 1250	1 360	12 750	100	8
14 O D	13 7750	13 87262	13 90387	13 91168	2 250	1 562	14 00	100	8
15 O. D.	14 76875	14 87418	14 90543	14 91324	2 350	1 687	15 00	100	8
16 O. D.	15 76250	15 87575	15 90700	15 91481	2 450	1 812	16 00	100	8
17 O D.	16 75625	16 87500	16 90625	16 91406	2 550	1 900	17 00	100	8
18 O. D.	17 7500	17 87500	17 90625	17 91406	2 650	2 000	18 00	100	8
20 O. D.	19 73750	19 87031	19 90156	19 90937	2 850	2 125	20 00	100	8
22 O. D.	21 72500	21 86562	21.89687	21 90468	3 050	2 250	22 00	100	8
24 O. D.	23 71250	23 86093	23.89218	23.89999	3 250	2 375	24 00	.100	8

A equals $G-(0.05G+1.9)\times\frac{1}{N}+\frac{0.8}{N}$

B equals $A+(F\times.0625)$

C equals $B+(\frac{4}{N}\times.0625)$

D equals $B+(\frac{5}{N}\times.0625)$

TABLE OF EQUALIZATION OF PIPES

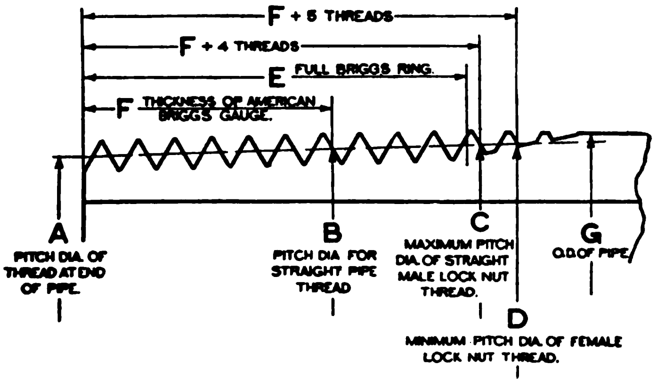
Dia. in's	⅛ in.	¼ in.	⅜ in.	½ in.	¾ in.	1 in	1¾ in.	1 ¾ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	4½ in.	5 in.	6
1-2	32	5 7	2 1	1												
3-4	88 2	15 6	5 7	2 8	1											
1	181	32	11 7	5 7	2 1	1										
1 1-4	316	55 9	20 3	9 9	3.6	1 7	1									
1 1-2	499	88 2	32 0	15.6	5 7	2 8	1 6	1								
2	1024	181	65 7	32	11 7	5 7	3 2	2 1	1							
2 1-2	5700	316	115	55 9	20 3	9 9	5 7	3 6	1 7	1						
3		499	181	88 2	32	15 6	8 9	5 7	2 8	1 6	1					
3 1-2		733	266	130	47	22 9	13 1	8 3	4 1	2 3	1 5	1				
4			370	181	65 7	32 0	18 3	11 7	5 7	3 2	2 1	1 4	1			
4 1-2			499	243	88 2	43 0	24 6	15 6	7 6	4 3	2 8	1 9	1 3	1		
5				316	15	55 9	32 0	20 3	9 9	5 7	3 6	2 4	1 7	1 3	1	
				499	181	88 2	50 5	32 0	15 6	8 9	5 7	3 8	2 8	2 1	1 6	1

Especially suited to the connection of oil burner or oil lubrication systems.

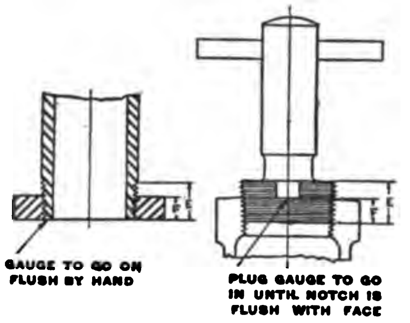
E equals $(0.8G+4.8)\times\frac{1}{N}+\frac{2}{N}$

F equals American Briggs Standard.
N equals Number of threads per inch.
Total Taper ¾ inch per foot.

Depth of Thread $\frac{0.8}{N}$


F + 5 THREADS
F + 4 THREADS
E FULL BRIGGS RING
F THICKNESS OF AMERICAN BRIGGS GAUGE
A
PITCH DIA. OF THREAD AT END OF PIPE
B
PITCH DIA. FOR STRAIGHT PIPE THREAD
C
MAXIMUM PITCH DIA. OF STRAIGHT MALE LOCK NUT THREAD.
G
O.D. OF PIPE
D
MINIMUM PITCH DIA. OF FEMALE LOCK NUT THREAD.

Cross Section of Standard Pipe Thread

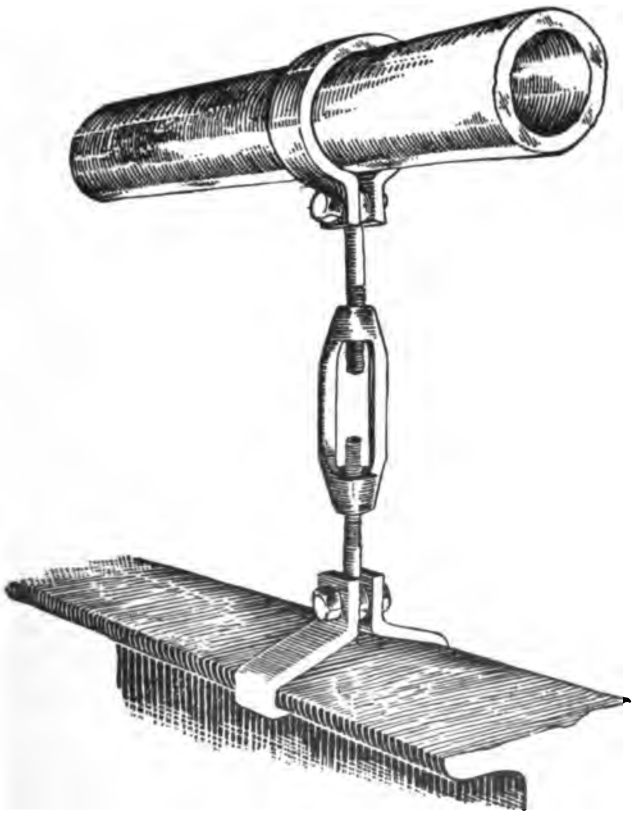

GAUGE TO GO ON FLUSH BY HAND
PLUG GAUGE TO GO IN UNTIL NOTCH IS FLUSH WITH FACE

ALLOWABLE VARIATIONS ARE: ONE THREAD LARGE OR SMALL

Courtesy Crane Co.

Hangers for Standard Pipe

Some time ago there was published in "Power" some information regarding hangers for pipes from two inches in diameter up to twenty-four inches. This data is published below with the thought that sewer pipe manufacturers and plants having hot floor dryers might be interested in the accompanying figures which illustrate how the pipe may be supported together with the dimensions of the pipe hanger parts and the safe load it will carry.

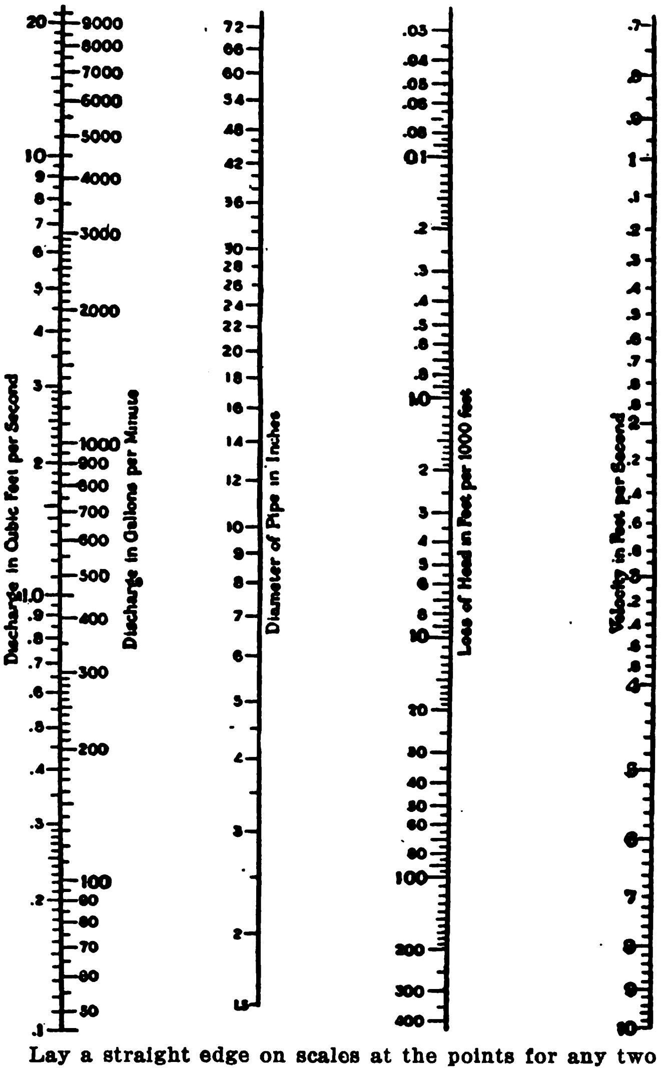


Sketch of a Pipe Hanger

Dimensions of Pipe—Hanger Parts

Pipe Size, In.	Pipe Band Thick., In.	Pipe Band Width, In.	Clamp Thick., In.	Clamp Width, In.	Rod, Diam., In.	Bolts Band, In.	Bolts Clamp, In.	Safe Load, Lb.	Length ½ Band, In.
2	¼	1¼	⅜	1¼	½	½x2	½x2¼	1,160	6
2½	¼	1¼	⅜	1¼	½	½x2	½x2¼	1,160	7
3	¼	1½	⅜	1½	½	½x2	½x2¼	1,160	8
3½	¼	1½	⅜	1½	½	½x2	½x2¼	1,160	9
4	¼	1½	⅜	1½	⅝	½x2	⅝x2¼	1,870	10½
4½	¼	1½	⅜	1½	⅝	½x2	⅝x2¼	1,870	11
5	¼	2	⅜	2	⅝	½x2	⅝x2¼	1,870	13
6	¼	2	½	2	⅝	⅝x2¼	¾x2¼	1,870	14
7	⅜	2	½	2	¾	⅝x2¼	¾x3	2,830	16
8	⅜	2	½	2¼	¾	¾x2¾	⅞x3¼	2,830	18
9	⅜	2	½	2½	⅞	¾x2¾	⅞x3¼	3,940	20
10	½	2	½	2½	⅞	¾x3	⅞x3¼	3,940	22
12	½	2¼	½	2½	1	⅞x3¼	1 x3[illegible]	5,180	25
14	½	2¼	½	2½	1⅛	1 x3½	1⅛x3¾	6,510	27
15	½	2½	½	2½	1⅛	1 x3½	1⅛x3¾	6,510	30
16	½	3	⅝	3	1⅛	1⅛x3¾	1¼x4	6,510	33
18	⅝	3	⅝	3	1¼	1⅛x4	1¼x4	8,410	35
20	⅝	3	¾	3	1¼	1¼x4	1¼x4½	8,410	37
22	¾	3	¾	3	1¼	1¼x4½	1¼x4½	8,410	39
24	¾	3	¾	3	1¼	1¼x4½	1¼x4½	8,410	42

Diagram for Calculating Pipe Sizes, Discharge Velocities, and Loss of Head in Water Pipe



Lay a straight edge on scales at the points for any two known quantities and the unknown quantities will lie at the intersection of the straight edge with the other scales.

67—BRICK BUILDING

The American Society for Testing Materials has a series of tests entitled "Standard Specifications for Fire Tests of Materials and Construction," which applies to Building Brick as well as other materials.

462—PIPE AND PIPE FITTINGS

Equalization Table

This table is based upon the laws of friction of gases in pipes, and is designed to equalize the combined capacities of a number of small pipes to that of the main conduit.

EXAMPLE—It is desired to connect thirty 8-inch pipes to one main, the problem being to determine the diameter of the latter. The usual rule would be to multiply the area of an 8-inch pipe by 30, resulting in a 44-inch main. By the table, it will be seen that thirty 8-inch pipes require a main of only 31 inches in diameter to carry the same volume of air.

The figures at the top of the column are the diameters of the branches, those at the left-hand side the diameter of the mains.

1	1														
2	5.7	2													
3	16	2.7	3												
4	32	5.7	2.3	4											
5	56	9.7	3.6	1.8	5										
6	88	16	5.7	2.8	1.6	6									
7	129	23	8.3	4.1	2.3	1.5	7								
8	180	32	12	5.7	3.2	2.1	1.4	8							
9	244	42	16	7.6	4.3	2.8	1.9	1.3	9						
10	317	56	20	9.9	5.7	3.6	2.4	1.7	1.3	10					
11	402	71	26	12	7.0	4.5	3.1	2.2	1.7	1.3	11				
12	501	88	32	16	9.0	5.7	3.8	2.8	2.0	1.6	1.2	12			
13	613	107	39	19	11	6.9	4.7	3.4	2.5	1.9	1.5	1.2	13		
14	737	129	47	23	13	8.3	5.7	4.1	3.0	2.3	1.8	1.5	1.2	14	
15	876	152	56	27	16	9.9	6.7	4.8	3.6	2.8	2.2	1.8	1.4	1.2	15
16	1026	180	65	32	18	11	7.9	5.7	4.2	3.2	2.6	2.1	1.7	1.4	1.2
17	1197	208	76	37	21	13	9.2	6.6	4.9	3.8	2.9	2.4	2.0	1.6	1.4
18	1374	239	88	43	24	16	10	7.7	5.7	4.3	3.4	2.8	2.3	1.9	1.6
19	1580	275	100	49	28	18	12	8.8	6.5	5.0	3.9	3.2	2.6	2.2	1.8
20	1775	312	114	56	32	20	14	9.9	7.4	5.7	4.5	3.6	2.9	2.5	2.1
21	1983	343	130	61	35	22	15	10	8.4	6.3	5.2	4.1	3.2	2.6	2.3
22	2250	398	145	71	41	26	18	13	9.3	7.2	5.7	4.5	3.7	3.1	2.6
23	2525	460	160	77	47	29	20	14	10	7.8	6.2	5 0	4.1	3.4	2.8
24	2800	493	180	88	50	33	22	16	12	8.9	7.6	5.7	4.6	3.8	3.2
25	3000	543	202	97	55	35	24	17	13	10	8.0	6.4	5.2	4.2	3.5
26	3425	590	219	108	62	39	27	19	14	11	8.6	6.9	5.7	4 7	4.0
27	3738	677	243	121	68	43	29	21	15	12	9.6	7.5	6.1	5.1	4.3
28	4100	725	265	129	74	48	32	23	17	13	10	8.3	6.8	5.7	4.8
29	4440	800	290	141	79	52	35	25	19	14	11	9.1	7.5	6.2	5.2
30	4898	864	315	151	88	56	38	28	20	16	12	9.9	8.0	6.7	5.7
31	5312	920	344	168	96	59	40	30	22	17	13	10	8.9	7.4	6.1
32	5631	1070	374	184	103	63	42	32	23	18	14	11	9.3	8.0	6.5
33	6154	1140	401	196	109	70	45	35	25	19	15	12	10	8.5	7.1
34	6675	1208	433	212	119	76	51	37	27	21	16	13	11	9.1	7.6
35	7075	1280	470	229	127	82	56	40	30	23	18	14	12	10	8.4
36	7735	1355	497	242	138	88	60	43	32	25	19	16	13	11	8.9
37	8205	1435	537	260	146	94	64	45	33	26	20	16	13	11	9.3
38	8715	1625	575	279	157	100	68	49	37	29	22	18	14	12	10

463—PIPE COVERINGS

Pipe Covering Specifications

The following information is abridged from the Specifications of the Magnesia Association of America and covers the subject fully.

All coverings of "85% Magnesia" consist of not less than 85% Magnesium Carbonate with sufficient asbestos fiber to give it structural strength.

Pipe-Covering Sections are 3 ft. long, made in halves for all sizes up to 10 in. pipe, and in segments for larger sizes.

Table No. 2

"85% Magnesia" Coverings for Boilers, Drums, Etc.

For	Thickness 1st Coat	Kind	Extra Covering	Total Thickness	Notes on Application
Boilers and Drums	2 in.	Block	1 in. plastic	3 in.	Finish with hard finishing cement to tops of walls, etc.
Drum-ends	3 in.	Block and plastic, or all plastic	....	3 in.	Wired on. Finish as above.
Boiler-walls	2 in.	Block and plastic, or all plastic	....	2 in.	Apply on expanded metal lath or V-rib netting. Case with metal to 4 ft. from floor
Breechings	......	(See	Boilers)	....	On ½ in. wire-cloth with 1 in. V-iron attached.
Heating Systems: Heaters, Receivers, Return-Tanks, Traps, etc.	Minimum 1½ in.	....	....	To equal thickness of pipe covering.	
Air Ducts, Flues, Fan-casings, coils, etc.	1 in.	Block	....	1 in.	Wired on with No. 18 galv'd wire. All joints pointed with plastic. Edges protected with light metal L-edging.

Table No. 1

"85% Magnesia" Coverings for Steam-Pipes

For	Size of Pipe	Thickness 1st Coat	Kind	Extra Covering	Total Thickness	Notes on Application
Pressures to 100 lbs. *(Standard thickness)............	½ in. to 1½ in. 2 in. to 3½ in. 4 in. to 6 in. 7 in. to 10 in. larger sizes........	⅞ in. $1\frac{1}{32}$ in. 1⅛ in. 1¼ in. 1½ in.	Sectional...... Sectional...... Sectional...... Sectional...... Segments......	....	⅞ in. $1\frac{1}{32}$ in. 1⅛ in. 1¼ in. 1½ in.	
Heating Systems...	....	as above....	....	....	....	....
Pressures 100-150 lbs......	All sizes..........	Double Standard Thickness				All joints broken (butt and lateral.) 1st layer wired on with No. 18 wire. All cracks filled with plastic "85% Magnesia."
150 lbs. and over........	.... All sizes..........	.... 1½ in.	.... Sectional......	1½ in......... Sectional......	.... 3 in.	
Superheat.........	All sizes..........	Double 1½ in....	Sectional......	½ in. Plastic...	3½ in.	
Drips (Superheat)..	All sizes..........	1½ in.	Sectional......	½ in. Plastic...	2 in.	
Drips (Saturated)..	See Standard Thickness (above)*					
Boiler-feed.........	See Standard Thickness (above)*					
Exhaust...........	See Standard Thickness (above)*					
Return............	See Standard Thickness (above)*					

Block Coverings are: 3 in. x 18 in., 3 in. x 36 in., 6 in. x 18 in., and 6 in. x 36 in.

Radiation Loss in Uncovered Iron Pipes

Units of heat (B. t. u.) emitted, per square foot, per hr. Temperature of air = 70 deg. F.

Mean temperature of pipes, Fahrenheit dgrees	By convection		By radiation alone	By convection and radiation combined	
	Air still	Air moving		Air still	Air moving
80	5.04	8.40	7.43	12.47	15.83
90	11.84	19.73	15.31	27.15	35.04
100	19.53	32.55	23.47	43.00	56.02
110	27.86	46.43	31.93	57.79	78.36
120	36.66	61.10	40.82	77.48	101.92
130	45.90	76.50	50.00	95.90	126.50
140	55.51	92.52	59.63	115.14	152.15
150	65.45	109.18	69.69	135.14	178.87
160	75.68	126.13	80.19	155.87	206.32
170	86.18	143.30	91.12	177.30	234.42
180	96.93	161.55	102.50	199.43	264.05
190	107.90	179.83	114.45	222.35	294.28
200	119.13	198.55	127.00	246.13	325.55
210	130.49	217.48	139.96	270.49	357.48
220	142.20	237.00	155.27	297.47	392.27
230	153.95	256.58	169.56	323.51	426.14
240	165.90	279.83	184.58	350.48	464.41
250	178.00	296.66	200.18	378.18	496.84
260	189.90	316.50	214.36	404.26	530.86
270	202.70	337.83	233.42	436.12	571.25
280	215.30	358.85	251.21	466.51	610.06
290	228.55	380.91	267.73	496.28	648.64
300	240.85	401.41	279.12	519.97	680.53

HEAT LOSSES FROM UNINSULATED HOT SURFACES

Temperature of surrounding air 70° F.

Steam Pressure (Gauge)	Steam Temperature (Deg. F.)	Difference between Temperature of Steam and Surrounding Air (Deg. F)	Loss Per Hour Per Sq. F. (B.T.U.'S.)	Waste of Coal in Lb. Per Sq. Ft. Per Year	Number of Sq. Ft. of Surface That Wastes a Ton of Coal in 1 Year
0	212	142	334	293	6.82
10	240	170	425	372	5.38
25	267	197	522.5	458	4.37
50	298	228	644	564	3.55
75	320	250	787.5	646	3.10
100	338	268	820	718	2.79
150	366	296	960	840	2.38
200	388	318	1,079	945	2.12
250	406	336	1,184	1,086	1.93

Above figures involving waste of coal are based on the following: 10,000 B.T.U.'s available per lb. of coal, which is equivalent to a boiler efficiency of 70%, using coal with an assumed heat value of about 14,000 B.T.U.'s per lb.

The figures are very conservative, as both the boiler efficiency and the heat value of the coal are high—a lesser boiler efficiency or inferior grade of coal would cause even a greater waste in pounds of fuel.

Correct Thickness and Methods of Application of "85% Magnesia" Coverings for Every Kind of Steam Service Heating Systems in Tunnels and other exposed places.

Cover all pipes with 1½ in. sectional "85% Magnesia."

Covering for Various Pressures and Temperatures

STEAM PRESSURES	STEAM TEMPERATURES	THICKNESS OF INSULATION
0 to 25 lbs.	212 to 267° F	1" or Standard*
25 to 100 lbs.	267 to 338° F	1½"
100 to 200 lbs.	338 to 388° F	2" or Double Standard*
Higher Pressures or Superheat	388 to 500° F	2½"
	500 to 600° F.	3"

For higher temperatures obtain special recommendations

* Standard and Double Standard thickness apply to 85% Magnesia Insulation only—other thicknesses apply to all types of insulation.

It is always preferable to apply insulation greater than 1½-inch thickness in two or more layers with all joints broken or staggered.

"Standard" thickness is as shown in table No. 1. This is the regular thickness in which all coverings are supplied.

To insure satisfaction all workmen should be skilled pipe-coverers and care should be taken that the quantities and instructions specified in these tables are exactly followed.

Outdoor Steam-Pipes.—Cover with double standard thickness protected with waterproof covering (see Finish).

Finish for all coverings.—See description after table No. 3.

Table No. 3
"85% Magnesia" Coverings for Flanges and Fittings

FITTINGS	Thickness	How Applied	Finish
Superheat	2½ in.	Blocks and plastic, or all plastic	Canvas Jacket
Superheat Drips	2 in.	as above	Rosin Paper and Canvas
Saturated (150 lbs. and over)	2½ in.	" "	Canvas
Saturated (100 lbs.)	2 in.	" "	"
Saturated (less than 100)	as pipes	" "	"
Saturated Drips	1½ in.	" "	Rosin Paper and Canvas
Flanges: For Superheat and Saturated steam over 100 lbs.	2 in.	Blocks and plastic, or all plastic, applied on frames of ½ in. wire netting	Canvas
Less than 100 lbs.	as pipe	as above	"
Heating Service	as pipe	Blocks and plastic, wired on	"
Exhaust: Fittings or Flanges	as pipe	Blocks and plastic, or plied on frames of ½ in. wire netting.	all plastic, ap-

Finish for All Pipes

Canvas Jacket.—All "85% Magnesia" coverings shall be finished with standard canvas jacket.

Extra Covering.—A second covering of canvas well sewed on with approximately 3 stitches per inch also affords greatly increased protection.

Rosin-sized Paper.—All exposed coverings when liable to damage should first be covered with rosin-sized sheathing-paper to be followed by canvas jacket as above.

Painting.—All canvas coverings should be sized and painted 2 coats of standard lead-and-oil color.

Bands.—Where required, metal bands shall be applied at distances not exceeding 18 inches apart.

Bolts, Manholes, etc.—All coverings should be neatly cut away and beveled to allow sufficient space for removal without injury to the covering.

Heating-Pipes.—Should be covered with canvas jacket and bound with black japanned bands, not more than 18 inches apart.

For Out-of-doors and Similar exposed positions.—Finish with 3-ply waterproof roofing in place of canvas. Apply with lapped joints, wired with No. 16 copper wires, not over 8 inches apart.

263—FIRE BRICK

Fire Brick Required in Plain Walls: 1 square foot 4½-inch wall requires 7 brick. 1 square foot 9-inch wall requires 14 brick. 1 square foot 13½-inch wall requires 21 brick. 30 brick per square foot of 18-inch wall; 1 cubic foot brickwork requires 17 9-inch brick; 7½ brick to each additional 4 or 4½ inches in thickness of plain walls per square foot.

To lay 1,000 brick requires from 250 to 320 pounds of fire clay or silica cement.

491—POTTERY, MATERIALS USED IN MANUFACTURE

Softening Points of Bone-Ash-Silica Mixtures

(O. Nielson.*)

No.	Formula	SiO_2 o/o	Softening Point
			°C.
0	$Ca_3P_2O_8$	....	1550
1	....	10	1440
2	$Ca_3P_2O_8$ $1SiO_2$	16.2	1450
3	....	20	1480
4	$Ca_3P_2O_8$ $2SiO_2$	27.9	1500
5	....	30	1445
6	$Ca_3P_2O_8$ $3SiO_2$	36.8	1630
7	....	40	1490
8	$Ca_3P_2O_8$ $4SiO_2$	43.7	1470

*Silika Ztg., 1913 (VI).

Melting Points of Silicates

G. Stein* has determined the melting points of the following silicates:

Metasilicate	Melting Point °C.	Orthosilicate	Melting Point °C.
$BSiO_3$	2000	Be_2SiO_4	2000
$MgSiO_3$	1565	Mg_2SiO_4	1900
$CaSiO_3$	1512	....	....
$FeSiO_3$	1500-1550	....	....
$MnSiO_3$	1470-1500	....	....
$ZnSiO_3$	1479	Zn_2SiO_4	1484
$SrSiO_3$	1287	Sr_2SiO_4	1593
$BaSiO_3$	1368.5	....	....

*Sprechsaal, 1908, No. 15.

Softening Points of Feldspar Mixtures

M. Urkas* has observed that not only are the melting points of mixtures of two crystalline substances lower than that of the more refractory constituent, but when such mixtures have been melted and allowed to cool, their melting point is often lower than that of the least refractory constituent. The following results were obtained:

(a) Mixtures of Orthoclase Feldspar (K_2O Al_2O_3 $6SiO_2$) and Olivine (MgO SiO_2)

Orthoclase	Olivine	Commencement of Softening of the Crystal	Commencement of Softening of the Mixture	Beginning of Softening of Glass	Beginning of Melting of Glass
o/o	o/o	°C.	°C.	°C.	°C.
90	10	1230	1300	1120	1150
80	20	1230	1300	1120	1150
70	30	1220	1260	1040	1100
60	40	1260	1325	1130	1160
40	60	1270	1380	1195	1240

(b) Mixture of Orthoclase, Olivine, and Anorthite†

Orthoclase	Anorthite	Olivine	Beginning of Softening of Crystal	Beginning of Melting of Mixture	Beginning of Softening of Glass	Beginning of Melting of Glass	Beginning of Solidification	End of Solidification
o/o	o/o	o/o	°C.	°C.	°C.	°C.	°C.	°C.
81	9	10	1220	1280	1080	1115	1100	1050
72	18	10	1200	1270	1090	1125	1105	1060
63	27	10	1250	1330	1120	1155	1125	1080
54	36	10	1280	1350	1125	1165	1150	1080
31.5	58.5	10	1220	1380	1230	1270	1240	1170

* Sprechsaal, 1908, No. 28.

† The average formula of anorthite is Ca_2O Al_2O_3 $2SiO_2$.

500—PULLEYS

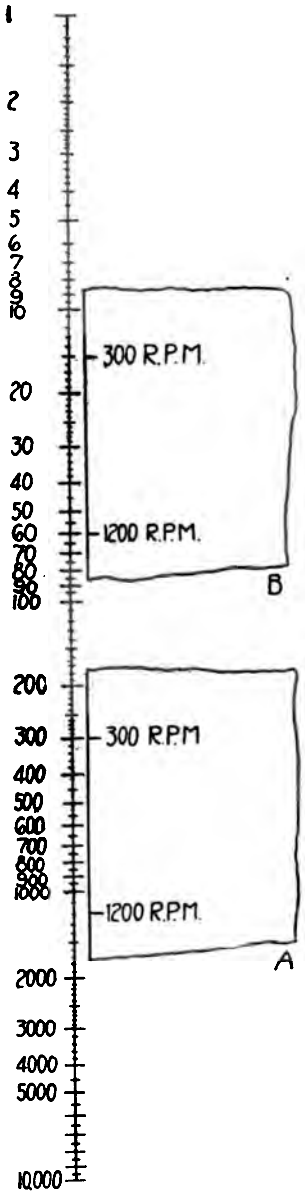


Chart to Determine Pulley Sizes and Speeds

A Chart for Quick Pulley Computations

This simple little chart does away with formulas for pulley computations. It will be found to be an exceedingly quick and satisfactory method of determining the sizes of two pulleys to be used in a drive, since in solving the problem it is only necessary to slide the paper from position "A" to position "B."

For example, a motor running at 1,200 r.p.m. is to drive a line shaft at 300 r.p.m. What sizes of pulleys should be used?

On the slip of paper in position "A" make marks opposite 300 and 1,200, as shown on the chart. While it really is unnecessary, it might be well to write 300 r.p.m. and 1,200 r.p.m. opposite these marks for the sake of insuring correct results.

Then slide the slip of paper up to wherever you want it. Position "B" shows that pulleys fifteen and sixty inches in diameter, respectively, will do the work very well.

Of course, if these diameters are considered too large, just move the slip a little higher until more suitable diameters are specified. No matter where the slip is placed, the ratio is always correct—no figuring is necessary.

The chart also lends itself readily to the solution of such a problem as, knowing the pulley diameters and knowing the speed of one of the pulleys, what is the speed of the other pulley?

Where a series of pulleys are being planned or the dimensions or speed must be accurate the formulas will give more satisfactory results.

Pulley Formulas

$$A = \frac{B \times S}{R} \qquad R = \frac{B \times S}{A}$$

$$B = \frac{A \times R}{S} \qquad S = \frac{A \times R}{B}$$

In which A=the diameter of the driver.

In which B=the diameter of the driven (both taken in feet or inches).

In which R=the revolutions of the driver.

In which S=the revolutions of the driven (both taken in the same interval of time).

To Determine Horse Power of Pulleys

Width of Single Leather Belt in Inches
Diameter of Pulley in Inches

Diameter of Pulley, in Inches	WIDTH OF SINGLE LEATHER BELT, IN INCHES																
	2	3	4	5	6	8	10	12	14	16	18	20	22	24	26	28	30
6	0.5	0.8	1.1	1.4	1.6	2.1	2.6	3.0	3.6	4.0	4.6	5.2	5.6	6.2	....	....	....
7	0.6	1.0	1.3	1.6	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.2	....	....	....
8	0.7	1.2	1.4	1.8	2.1	2.8	3.4	4.1	4.8	5.4	6.2	6.9	7.6	8.2	....	....	....
36	3.1	4.8	6.4	7.9	9.4	12.6	15.6	18.8	22.0	25.2	28.3	31.4	34.6	37.6	....	....	....
38	...	...	6.8	8.3	10.0	13.2	16.6	19.9	23.3	26.6	30.0	33.2	36.5	39.8	....	....	....
40	...	...	7.1	8.8	10.5	14.0	17.4	20.9	24.5	28.0	31.5	35.0	38.4	42.0	45.4	49.9	52.4
42	...	...	7.4	9.2	11.0	14.7	18.4	22.0	25.7	29.4	33.0	36.6	40.4	44.0	47.6	51.3	55.0

The horse powers of all other pulleys whether larger, smaller or intermediate, are in direct proportion to those shown. The basis of the table is that a single leather belt one inch wide traveling at the rate of 600 feet per minute, or a double leather belt one inch wide, traveling at 382 feet per minute transmits one horse power. Working load of belt equals 55 pounds per inch of width of single belt. To find horse power of double belts multiply the horse powers given in the table by ten-sevenths. This table is based on speed of 100 revolutions per minute in the case of either driving or driven pulleys.

501—PULLEYS, SPECIAL AND SLOTTED

The Economy of Cork Inserts

This is an important topic that has not been written about or discussed to such an extent as have other transmission devices. Why this is so is unexplainable. It is a worthy subject because cork inserts are as much an economy factor as the other devices that stop belt slip. The principal functions of the cork insert is to stop all avoidable belt slip. In doing this considerable coal and money may be saved.

To compute the cost of belt slip it is first necessary to find the percentage of belt slip. That is, if a driven pulley rotates only 92 times, whereas it should rotate 100 times, the percentage of belt slip is 8 per cent., or

$$\frac{100-92}{100}=8 \text{ per cent.}$$

Then multiply the determined per cent. of slip by the number of tons of coal burned per year, and then by the cost of the coal per ton. Thus we have

$$(2{,}000\times\$3\times.08=\$480)$$

the yearly cost of belt slip.

Thus where 2,000 tons of coal are burned per year where coal costs $3 per ton, and where the over-all belt slip is eight per cent., the cost of the belt slip in terms of the coal pile alone is $480.

To arrive at the actual and accurate cost of belt slip is not easy, however. It is plainly more than $480 in such a plant as above, because coal is not the only thing that is lost. The belts wear out more rapidly where there is slip, and the cost of this slip can only be approximated.

Let us assume, for example, that with cork inserts a plant manages to keep its belts running for ten years. The first cost of the belts is, say, $5,000. The average cost, then, is $500 per year. Without cork inserts the belts wear out in eight years, and the average cost is $625 per year. This would mean a saving of ($625—$500) $125 per year, or $1,250 in ten years. As these figures may not apply to every plant, this formula may be used and the reader can substitute his own conditions.

Formula for Finding Saving Due to Cork Inserts

Dollars saved with cork inserts from belt cost standpoint only, equal

$$\frac{(Nc-N)\ K}{N}$$

where Nc=life of belt in years with cork inserts,
N=life of belt in years without cork inserts,
K=first cost of belt in dollars.

The cost of lost product must also be considered. The value of cork inserts appears here again, and the problem can be approximated mathematically. Let us take, for example, the above plant where over-all belt slip is 8 per cent. and where the output should be worth, without slip, $2,000 per day. With 8 per cent. slip it is evident that the machines are running 8 per cent. too slow and the product is, therefore, diminishing by 8 per cent. Hence, the daily output is approximately

$$\$2{,}000-(\$2{,}000\times8\%)=\$1{,}840 \text{ instead of } \$2{,}000.$$

To make the formula clearer, and to enforce this cost on the mind of the plant owner, we have thrown it into this form:

$$\text{Dollars output lost per day}=\frac{D}{1-S}-D$$

where D=present daily output in dollars;
S=per cent. of belt slip.

Thus, if your present daily output amounts to $1,500, and if your over-all belt slip is 10 per cent., we have, after substituting in the formula

$$\frac{1{,}500}{1-.10}-\$1{,}500=\$1{,}667-\$1{,}500=\$167.$$

One hundred and sixty-seven dollars lost per day is considerable and may mean the ruin of a small plant, unless discovered and rectified. This "product loss" is often saved by speeding up the driving engines or motors to the extent that after belt slip is deducted the final speed is what it should be anyway. That method is better than none at all, but it is not the best practice. The best practice is to eliminate all belt slip.

Thus comes the cost of defective product. Where belt slip is permitted, the product frequently suffers on that account. The loss cannot be figured mathematically, because it is too uncertain. It may vary from a trifling to a very serious amount. To reduce this loss to the minimum, belt slip must be completely eliminated. By so doing, all machines are driven by steady speeds. There is no bunching here and thinning there. Production is uniform, day in and day out. Such is the ideal state as regards speed, and the value of cork inserts is further emphasized.

See also entries in both Definition and Statistical Sections under Countershaft, Shafting, Belting, Gear, Conveyor, Belt and Drive, belt.

504—PUMP

General Information

Boiler feed pumps of either the single or duplex type consume from 130 to 200 pounds of steam per horse power hour. Simple pumps to elevate water consume 120 pounds of steam per horse power hour.

To determine the horse power necessary to elevate water to a given height multiply the total weight of the column of water in pounds by the velocity of the water in feet per minute and divide the product by 33,000. In order to take care of friction and other losses, an allowance of 25 per cent. should be made in this figure.

To determine the capacity of a pump multiply the area of the water piston in inches, by the distance it travels in inches, in a certain time. Divide this product by 231 and the result will be the capacity in gallons in the time used.

The ordinary speed of pumps is 100 feet of piston travel per minute.

To find the quantity of water elevated in one minute, running at 100 feet per minute piston speed, square the diameter of the water cylinder in inches and multiply by 4.

To find the diameter of a pump cylinder necessary to move a certain quantity of water at a piston speed of 100 feet per minute, divide the number of gallons by four, and extract the square root of the result. This final result will be the required diameter in inches. In case of a duplex pump divide the number of gallons by two before starting the computation.

To find the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144 and divide the result by the area of the pipe in inches.

The area of a steam piston multiplied by the steam pressure gives the total amount of pressure exerted. The area of the water piston multiplied by the pressure of water per square inch gives the resistance. The power exerted must be larger than the resistance by an amount sufficient to move the piston at the required speed.

See also pipe, statistical section.

524—REFRACTORIES

Heat Conductivity Data on Some Commercial Refractories

Data on the heat conductivity of the different commercial refractories is very limited and such data as is published is somewhat confusing owing to the fact that the conditions of preparation or test are not comparable with industrial conditions.

The data quoted in most engineering literature has been taken from the research by Wologdine and Queneau—Electro Chemical and Metallurgical Industry, Sept. and Oct., 1909. The data from this research bearing on heat conductivity is compiled in the following table:

Table I. Heat Conductivity of Refractories by Wologdine and Queneau

Type of Refractory	Deg. C. Burning Temp.	Average Deg.C. Temp. of Test		Average Heat Conductivity. Gram, calories, sec. Cm.² Cm. per 1° C. diff.	Relative Heat Conductivity
		Upper Surface	Lower Surface		
Clay Fire Brick...	1050	135	905	0.0037	16.7%
Clay Fire Brick...	1300	250	865	0.0051	
Clay Fire Brick...	1050	225	1160	0.0035	
Clay Fire Brick...	1300	225	880	0.0042	
Bauxite Brick....	1050	155	1130	0.0031	13.2%
Bauxite Brick....	1300	170	1060	0.0033	
Silica Brick......	1050	110	1005	0.0020	7.8%
Silica Brick......	1300	154	928	0.0031	
Magnesite Brick..	1050	230	1000	0.0058	28.4%
Magnesite Brick..	1300	185	915	0.0060	
Chromite Brick...	1050	165	1050	0.0028	22.8%
Chromite Brick...	1300	120	990	0.0034	
Carbordm. Brick..	1050	267	695	0.0145	92.4%
Carbordm. Brick..	1300	265	545	0.023	
Carbordm. Brick..	1050	175	1077	0.0033	
Carbordm. Brick..	1300	314	757	0.014	
Graphite Brick...	710	152	696	0.0059	100.0%
Graphite Brick...	1050	330	575	0.024	
Graphite Brick...	1300	357	595	0.025	

This data has the fault of unsatisfactory burning of the test specimens. The firing temperatures of the brick were 1,050 deg. C. and 1,300 deg. C. or approximately cones 05 and 9, respectively. The lowest temperature employed for burning any refractory is cone 12 or approximately 1,370 deg. C., while the magnesite and chrome brick are burned at temperatures above 1,500 deg. C. It is, therefore, doubtful whether the values presented in the preceding article are reliable as representing the heat conductivities of the same refractories fired under normal temperatures. C. S. Kinnison, formerly with the U. S. Bureau of Standards, calls attention to this fault in the above data (see Brick & Clay Record, April 21, 1914) and explains that if the silica brick were fired at the normal burning temperature of that refractory, it would have a heat conductivity equal to or greater than that of the fire clay brick. He indicates in the same article that the clay bonded quartzite brick should be superior to either silica or fire clay brick as regards heat conductivity.

The next article on conductivity of refractories to appear was The Thermal Conductivity of Refractory Materials, by G. Dougill, H. J. Hodsman and J. W. Cobb—Jour. Sec. of Chem. Industry, Vol. 34, page 465, May 15, 1915.

The conductivity data in this article is contained in the Table II:

All these test specimens were burned under industrial conditions but unfortunately the burning temperatures are omitted from the article except in the case of the fire clay brick. It is also unfortunate that the test specimens varied so greatly in thickness.

A recent contribution to data on heat conductivity of refractories is the article "Thermal Conductivity of Refractory Brick," by W. Van Rinsum, Science Abstracts "B," Jan. 30, 1920, p. 18, also Chem. Abstracts, Vol. 14, No. 9, May 10, 1920, p. 1420.

In the investigation of which the following is a progress report, no pretense is made to scientific methods of procedure, the only consideration being the following:

(a) The test specimens are normal samples of commercial ware on which the burning temperature is known.

(b) The test specimens are of the same thickness so far as possible. All are exactly as made and burned except the magnesite brick which was tested in the original thickness and later cut down by grinding off one face, thus reducing it to the same thickness as the other specimens.

Table II. Thermal Conductivity of Refractory Materials, By Dougill, Hodsman and Cobb

Specimen	Thickness, Inches	Deg.C. Lower Face	Deg.C. Upper Face	Mean Conductivity	Remarks
Fire Clay Brick...	1½	825	260	0.0029	Fired to Cone 10-11
Fire Clay Brick...	1½	970	300	0.0029	
Fire Clay Brick...	1½	1080	330	0.0036	
Fire Clay Brick...	1½	1100	420	0.0035	
Fire Clay Brick...	1½	1350	510	0.0039	
Fire Clay Brick...	1½	1440	550	0.0040	
Fire Clay Brick...	1½	1005	....	0.00165	Fired to Cone 8-9
Fire Clay Brick...	1½	1020	....	0.00120	
Siliceous Clay Brick..........	3	1300	310	0.0025	Many silica grs.
Silica Brick......	2½	995	295	0.0030	
Silica Brick......	2½	1210	370	0.0035	
Silica Brick......	2½	1395	440	0.0042	
Magnesia Brick...	2½	380	270	0.0170	
Magnesia Brick...	2½	560	325	0.0151	
Magnesia Brick...	2½	600	400	0.0148	
Magnesia Brick...	2½	700	450	0.0132	
Magnesia Brick...	2½	750	470	0.0116	
Magnesia Brick...	2½	875	525	0.0110	
Magnesia Brick...	2½	1025	580	0.0101	
Magnesia Brick...	2½	1040	590	0.0098	
Magnesia Brick...	2½	1370	690	0.0091	

(c) The test furnace was an electrically heated furnace capable of maintaining an approximately constant temperature for a period of eight to ten hours.

(d) Each test was continued until a state of practical equilibrium existed. To insure this, the test was continued until the temperature change on either side of the test specimen did not exceed five degrees per hour.

(e) The conditions of test were maintained constant as regards drafts, the furnace being so located that the exposed face of the test specimen was cooled only by normal radiation.

(f) The same insulating arrangement is provided for all specimens. This consists of kieselguhr cleats cut to fit and extending three quarter inch over the edges of the brick, thus preventing radiation of heat along the line of contact between the furnace and the test specimen.

Table III. Gives the Important Data on Thermal Conductivity of Refractory Brick, by W. Van Rinsum

Specimen	Chemical Analysis		Kg. Calories per Hour, per Meter, per Deg. C.		
	SiO_2	Al_2O_3	200 Deg.C.	600 Deg.C	1000Deg.C.
Silica......................	96	2	0.48	0.81	1.13
Silica......................	....	....	0.51	0.88	1.24
Silica—quartzite............	95	1	0.68	0.94	1.20
Dinas.......................	63	33	0.76	1.02	1.27
Dinas.......................	66	31	0.72	0.85	0.98
Fire Clay (Chamotte) retort blocks...........	....	....	0.52	0.68	0.83
Fire Clay (Chamotte).........	....	....	0.49	0.64	0.80
Magnesite..............	....	....	....	1.29	1.40

(g) Standardized copper — constantan thermocouples were used and the voltage measurements determined by means of a Leeds & Northrup potentiometer.

The Test Furnace

This is a Standard Type, F. B. 204, Hoskins Mfg. Co., furnace with hairpin type of heating units. The door has been removed and replaced by movable cleats of kieselguhr so cut that they insulate the edges of the test specimens. A thermocouple is inserted thru the back of the furnace and extends to within 2 cm. of the inside face of the test specimen when located in position in the kiln door. Another thermocouple is looped over the top of the test specimen in such a way that it presses securely against the face of the center of the test piece on the furnace side. A third thermocouple is pressed tightly against the outside of the test specimen directly opposite the inside contact couple. The object in having the extra thermocouple removed 2 cm. from the inside face of the trial piece is to furnish the actual temperature of the furnace, and thus show to what extent the contact couple is affected by the heat conductivity of the test specimen.

The test data submitted indicates that the thermal conductivity of the test specimen distinctly influenced the temperatures of both the inside contact thermocouple and the thermocouple 2 cm. removed.

No tests were attempted with insulation on the outside face of the brick but tests conducted in this manner are proposed and will be conducted later.

The Test Specimens of Refractories

These are standard splits which are 1¼ inch thick and of the same other dimensions as standard fire brick. The Harbison Walker Refractories Co., of Pittsburgh, Pa., furnished the following:

Fire clay brick "Benizet" brand.......fired at cone 13
Bauxite brick ....fired at cone 15
Silica brick "Star" brand ....fired at cone 17
Magnesia brick ....fired at cone 20
Chrome brick ....fired at approximately cone 26

The M. D. Valentine & Bro. Co., of Woodbridge, N. J., furnished the following:

N. J. clay brick, fired at cone 11 and 12.

Interpretation of Data

It becomes necessary to devise some system of expressing the data in Table IV in comparable values and for convenience we will determine the temperature gradient.

$$\text{Temperature gradient} = \frac{a-b}{d}$$

a=temperature of hot side of test specimen.
b=temperature of cold side of test specimen.
d=diameter of test specimen expressed in cone.

This formula is not absolutely accurate and where the diameters of test specimens differ, a distinct error is introduced by the use of the value "d." Comparison of the two values for magnesia brick at 4 and 3 cm. diameters support this opinion but more work must be done before a definite statement can be made. Such an error is, however, not vital in this data, because all test specimens are practically the same diameter.

Following the example of Wologdine and Queneau, it is also proposed to express the relative heat transfer of the different refractories as decimals of the heat transfer of some constant substance.

Graphite brick was chosen as unity by Wologdine and Queneau, but this is not practical since it changes composition on heating, due to oxidation of the graphite. A hard steel was finally chosen and from a bar of this a test specimen was cut of the same dimensions as the refractory test specimens. This was tested in the same manner as the other test specimens and the values presented in Table V.

Table V. Comparative Temperature Gradients

Specimen	Diameter cm.	Temperature Gradient	Relative Transfer of Heat
Normal Fire Clay	3.1	174	0.448
High SiO_2 Fire Clay	3.1	170	0.459
Bauxite	3.1	163	0.478
Silica	3.3	152	0.513
Magnesia	4.0	125	0.624
Magnesia	3.1	135	0.578
Chrome	3.15	108	0.722
Hard Steel	3.0	78	1.000

The above values are merely relative and must be so considered. The wisdom of using steel as unity is open to question, since its absorption and radiation properties are widely different from those of the refractories. The relative heat conductivity may or may not be proportional to the temperature gradient of the different refractories. If it is proportional, then the relative values of the refractories as heat insulators would be as follows:

Fire clay refractory	1.00
High silica clay refractory	0.974
Bauxite refractory	0.937
Silica refractory	0.873
Magnesia refractory	0.776
Chrome refractory	0.621

The influence of having an insulating material of constant thickness and composition over the outside surface of the test specimens has not been studied. The imbedding of the thermocouple terminals in the refractories may also result in very different values.

The foregoing data was presented by Arthur S. Watts with the hope that discussion might be created and a decision reached as to whether this type of data has definite importance in the measurement of industrial values of refractory products.

Table IV. Data on Heat Conductivity of Refractories, by Arthur S. Watts

Legend of Temperatures:
Couple inside furnace 2 cm. from test specimen.
Couple inside furnace in contact with test specimen.
Couple outside furnace in contact with test specimen.

SPECIMEN	Temperature at End of Time Indicated.										
	3 Hr.	3½ Hr.	4 Hr.	4½ Hr.	5 Hr.	5½ Hr.	6 Hr.	6½ Hr.	7 Hr.	7½ Hr.	8 Hr.
Fire Clay "Beniset" 3.1 cm. thick, cone 13	825 815 308	836 828 315	858 855 325	....	860 858 325	....	868 865 330	....	875 870 330	....	877 870 330
N. J. Fire Clay, 3.1 cm. thick, cone 12	810 803 308	820 818 317	....	840 836 320	....	854 854 330	854 854 335	860 858 335	....	865 862 335	....
Bauxite, 3.1 cm. thick, cone 15	750 740 298	....	820 810 335	....	....	....	850 837 342	857 850 343	859 854 347	862 856 347	865 856 350
Silica, 3.3 cm. thick, cone 17	738 713 291	....	810 810 330	836 834 335	846 844 340	....	854 850 348	858 855 350	860 855 353	....	....
Magnesia, 4. cm. thick, cone 20	725 710 316	....	822 818 335	....	832 825 335	....	832 827 338	....	843 835 344	....	854 846 347
Magnesia, 3.1 cm. thick, cone 20	....	730 718 340	787 785 380	....	794 794 384	800 798 385	....	806 804 385	....	....	....
Chrome, 3.15 cm. thick, cone 26	630 580 270	....	....	740 715 390	776 752 422	....	790 770 430	....	795 775 436	....	795 780 440
Hard Steel, .85 carbon, 3.0 cm. thick	670 625 402	....	710 666 440	....	735 685 460	....	740 695 465	....	758 710 475	....	760 715 480

Load Test

The American Society for Testing Materials Has Adopted the Following Standard Test for Refractory Materials Under Load at High Temperatures.

The object of this test is to determine the resistance of the specimen to deformation at a specified temperature for a specified time, when subjected to a compressive load of 25 lb. per sq. in. (1.765 kg. per sq. cm.).

The apparatus consists essentially of a furnace and loading device. It shall be constructed in accordance with Figs. 1 and 2.

The furnace shall be cylindrical in form, 18 in. (457 mm.) in internal diameter, as shown in Fig. 1.

The heating shall be done with gaseous or oil fuel and compressed air, using not less than two burners located tangentially and so arranged that no flame can impinge upon the test specimen. The burners shall be such as will insure a uniform temperature in all parts of the furnace and be under complete control.

The method of loading shown in Fig. 1 shall be used, and the details shall be such as will insure accuracy in the applied load and freedom from eccentric loading, both in the original application and during the test. It is advantageous to make the cross-beams as light as possible, so that the greater portion of the load may be concentrated in the weights.

The temperature may be measured either with a calibrated platinum-rhodium thermocouple, encased in a double protecting tube with the junction not more than 1 in. (25 mm.) from the side or edge of the specimen and approximately opposite the center; or with some form of optical pyrometer that has been calibrated against a thermocouple in the furnace. If the thermocouple is used, the cold-end temperature should be kept constant in melted ice. A recording form of indicator is recommended where possible.

The test specimen shall consist, whenever possible, of a standard 9-inch brick placed vertically on end. In the case of blocks or shapes, sections approximately 9 by 4½ by 2½ in. (228 by 114 by 64 mm.) shall be cut, utilizing as far as possible existing plane surfaces. The ends of the specimen shall be either ground so that they are parallel and perpendicular to the vertical axis, or if this is impossible, shall be bedded in a neutral cement, so that the specimen is perpendicular to the base of the furnace.

The test specimen shall be measured before testing, making not less than five observations in each direction to within + or — 0.02 in. (0.5 mm.). The average dimensions shall be reported, and the cross-section calculated.

The test specimen shall occupy approximately the center of the furnace and should rest on a block of some highly refractory material, having a minimum expansion or contraction. A silicon-carbide brick has been found satisfactory. At the top of the test specimen a block of similar highly refractory material should be placed, extending thru the furnace top to receive the load.

NOTE.—Gross errors which may more than double the contraction will result if the specimen is not set perpendicular to the base of the support or if the load is eccentrically applied.

The rate of heating shall be in accordance with the requirements of Table I and the time-temperature curves of Fig. 3, which give the rate and time of heating suggested for different grades of material.

The load is calculated from the average cross-section as determined on the untested specimen and the requirement of the test. It is recommended that for general purposes, 25 lb. per sq. in. (1.765 kg. per sq. cm.) be used.

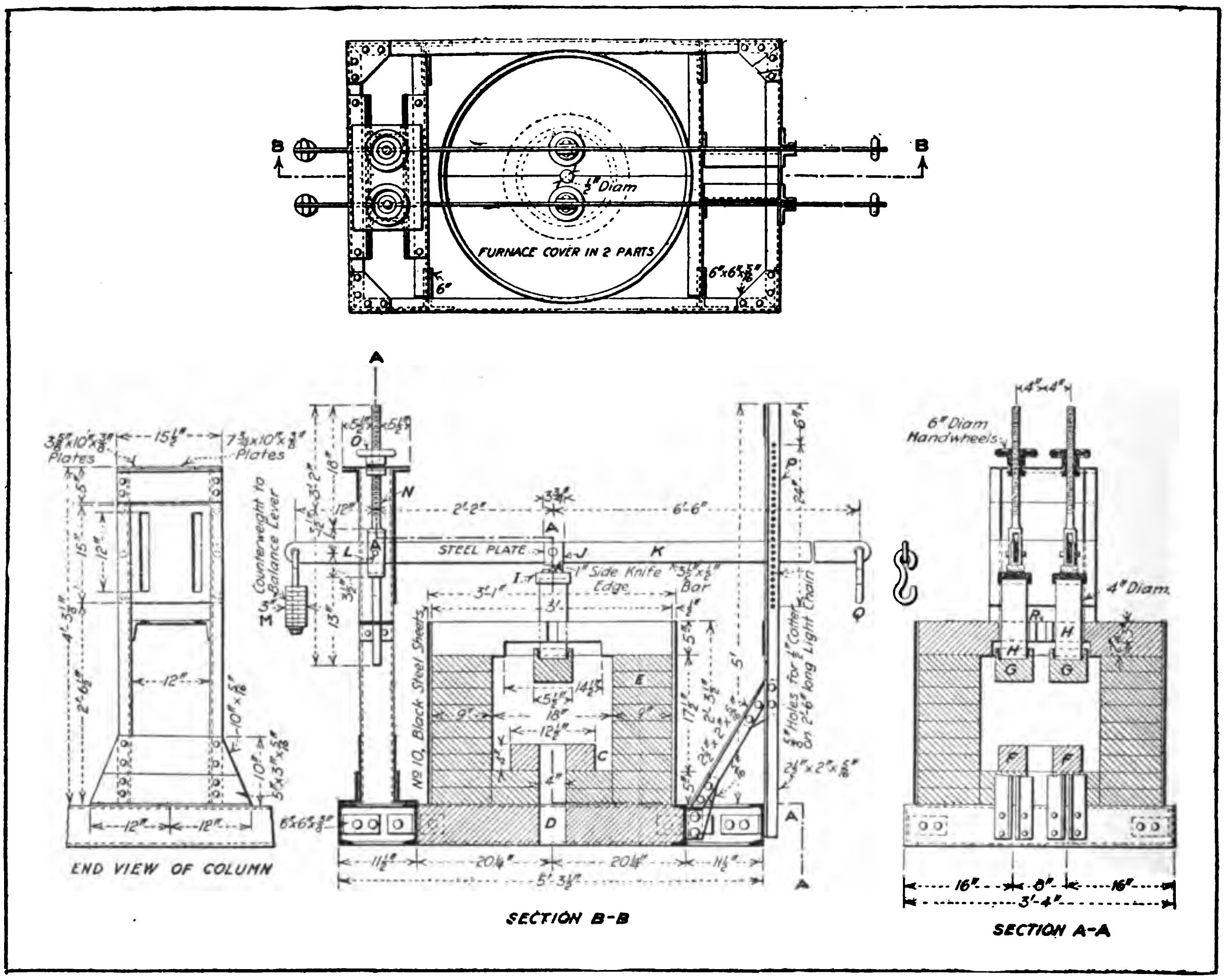


Fig. 1. Apparatus for Testing Refractory Materials Under Load at High Temperatures

The additional masses required to give the desired loading should be equally distributed on each side of the beam.

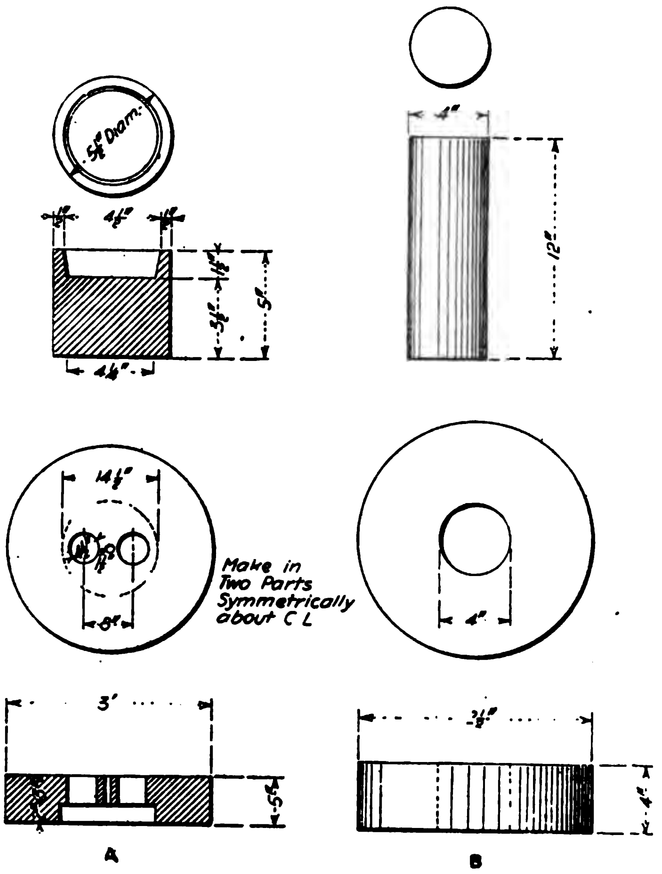


Fig. 2. Special Shapes Required for Furnace

At the expiration of the time of heating, the supply of heat shall be stopped and the furnace allowed to cool, during not less than 5 hours before removing the load and examining the test specimen.

NOTE.—The specimen shall be examined immediately after the heating is stopped for evidences of cracking and spalling, as such defects may develop later due to the rapid cooling of the furnace.

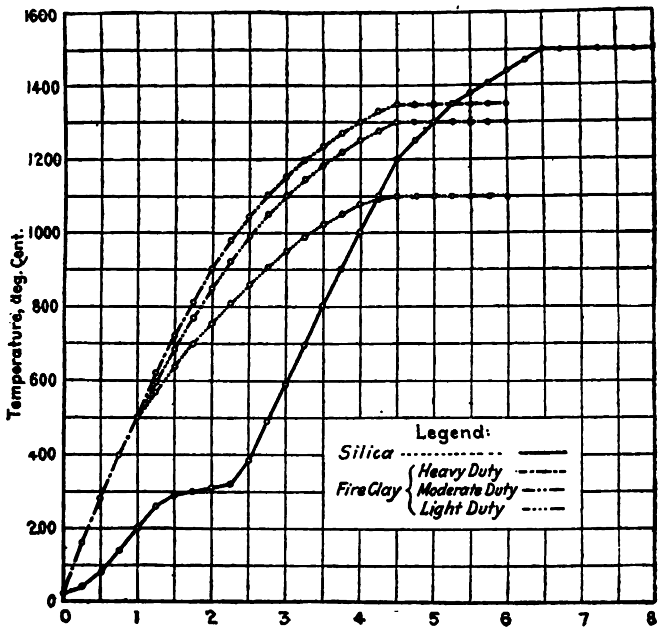


Fig. 3. Time-Temperature Curve for Load Test

After the test specimen has cooled to the room temperature, it shall be remeasured as before described, and the change in length recorded and reported as percentage of the original length.

NOTE.—It is recommended that a photograph be made of the specimen before and after testing, as yielding valuable information at a minimum time and expense.

Table I. Temperature to be Attained at Time Specified
All Temperatures in Degrees Centigrade

Time		Silica	Fire Clay		
			Heavy Duty	Moderate Duty	Light Duty
Hr.	Min.				
	15	40	160	160	160
	30	80	280	280	280
	45	140	400	400	400
1	0	200	500	500	500
	15	260	620	595	570
	30	290	720	685	640
	45	300	815	770	700
2	0	310	900	850	755
	15	320	980	920	810
	30	385	1045	990	860
	45	490	1100	1050	905
3	0	590	1150	1100	950
	15	695	1195	1145	985
	30	800	1235	1185	1020
	45	900	1270	1220	1050
4	0	1000	1300	1250	1075
	15	1100	1230	1275	1090
	30	1200	1300	1300	1100
	45	1250	1350	1300	1100
5	0	1300	1350	1300	1100
	15	1350	1350	1300	1100
	30	1380	1350	1300	1100
	45	1410	1350	1300	1100
6	0	1440	1350(End)	1300(End)	1100(End)
	15	1470			
	30	1500			
	45	1500			
7	0	1500			
	15	1500			
	30	1500			
	45	1500			
8	0	1500(End)			

Porosity and Permanent Volume Change

The American Society for Testing Materials Has Adopted the Following Standard Test for Porosity and Permanent Volume Changes in Refractory Materials:

The object of this test is to determine the porosity and permanent volume changes in refractory materials when heated to series of specified temperatures.

The sample shall consist of at least seven standard-size brick.

Test specimens measuring 2½ by 2½ by 1¼ in. shall be cut so as to remove the original surfaces of the brick; for this a "cut off" grinding wheel is recommended. There should be five test specimens for each of the seven heat treatments specified below or 35 test specimens for each kind of brick. The test specimens shall be brushed or washed free from all adhering dust and marked serially with a refractory stain, for which 5 per cent. cobalt-kaolin mixture is suggested.

After the test specimens have been cut and cleaned, they shall be dried and the volumes and porosity of each obtained as described on page 192. They shall be heated as specified below, and the changes in volume and porosity determined.

Dry the test pieces prior to placing in the kiln.

Raise the temperature as rapidly as is consistent with even heat distribution to 1200 deg. C. From 1200 deg. C. raise the temperature at the rate of 30 deg. per hour, drawing samples at each 50 deg. interval from 1200 to 1500 deg. C.

If it is possible and the number of brands being tested warrant, it is best that separate burns to each temperature be made and the kiln sealed and allowed to cool by radiation. In case separate burns cannot be made, the five test specimens from each temperature increment should be covered with hot sand immediately on being drawn;

or placed in a supplementary furnace and kept at about 500 deg. C. until all drawings are completed, and then cooled with the furnace sealed to cool wholly by radiation.

Method of Obtaining Data

The test specimens shall be cleaned from adhering or loosely attached pieces and particles, care being taken not to alter the exterior volume as originally prepared for this test.

The test specimens shall be heated if necessary to 110 deg. C. to remove moisture, and their dry weight (D) obtained to 0.10 g.

The test specimens shall be placed in kerosene of known density (δ) under a vacuum of 25 in. for four hours at 25 deg. C. and cooled to room temperature while yet immersed.

When cool, each test specimen shall be weighed suspended in kerosene at 25 deg. C. to determine its Suspended Weight (S), in grams.

The Saturated Weight (W), in grams, of each test specimen shall be obtained immediately after obtaining the suspended weight, by drying lightly with a kerosene-moistened towel to remove the excess kerosene and then weighing in air.

The Exterior Volume (V), in cubic centimeters, of each test specimen is obtained by subtracting the suspended weight (S) from the saturated weight (W), and dividing by the density (δ) of the kerosene. Thus,

$$V=\frac{W-S}{\delta}\ \ldots\ldots\ldots\ldots\ldots\ldots \tag{1}$$

The Actual Volume of Open Pores (V_1), in cubic centimeters, is obtained by subtracting the dry weight (D) from the saturated weight (W), and dividing by the density (δ) of the kerosene. Thus:

$$V_1=\frac{W-D}{\delta}\ \ldots\ldots\ldots\ldots\ldots\ldots \tag{2}$$

The Apparent Specific Gravity (T_1) of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights, and multiplying by the density of the kerosene. Thus,

$$T_1=\frac{D}{D-S}\delta\ \ldots\ldots\ldots\ldots\ldots \tag{3}$$

The True Specific Gravity (T) of the wholly solid or burned clay portion is obtained by crushing a portion of the dried test specimen to 120-mesh powder and determining the displacement at 25 deg. C. under 24 in. vacuum, of a 20-g. sample in a 50-cc. straight-wall pyknometer using kerosene, and correcting for density of the kerosene.

The Volume of Sealed Pores (V_2), in cubic centimeters, is obtained by subtracting the quotient of dry weight (D) divided by true specific gravity (T) from the volume of the impervious portion of the test specimen; or

$$V_2=\frac{(D-S)}{\delta}-\frac{D}{T}\ \ldots\ldots\ldots\ldots\ldots \tag{4}$$

The Volume Shrinkage is obtained by subtracting the volumes, that is, the values of $\frac{W-S}{\delta}$, before and after the heat treatment.

To show progressive changes in the several volumes, refer all volumes back to the original exterior volume of the test specimen as 100. This is done by multiplying all volumes by the factor 100/V, in which V is the exterior volume of the test specimen prior to the subjection to heat treatment.

The volume data should be determined for each test specimen and multiplied by the above factor to reduce all volumes for each test specimen to terms of 100 original exterior volumes of that test specimen before the average of the five for each heat treatment is calculated.

Slagging Action

The American Society for Testing Materials has suggested the following tentative method of test for slagging action of refractory materials.

Select three or more of the bricks to be tested. Draw upon the smooth or unbranded side a line bisecting each brick across the narrow dimension. Draw diagonals across each half. The points of intersection of the diagonals locate the centers of rings. Where samples do not conform to the standard 9-in. brick, one or more points may be located on any flat smooth surface, provided the centers of rings do not approach closer than 2 in. to any edge of that surface, and if more than one point is chosen, the centers lie not closer than 4½ in. from each other.

The rings used are made from clay, molded under pressure, dried and burned. The mix from which the rings are made is as follows:

55 per cent., by weight, of highly refractory flint clay, calcined and ground to pass a 20-mesh sieve and remain on a 60-mesh sieve;

45 per cent., by weight, of first-quality plastic fire clay ground to pass a 20-mesh sieve.

Approximately 9 per cent. by weight of water is added to the above mix and the whole is then thoroly mixed and finally rubbed thru a 10-mesh sieve. The best results are obtained if at this point the mix is allowed to stand for a few days, precaution being taken to prevent evaporation of the water.

The rings are molded in a four-piece steel mold, Fig. 1. The two pieces A and C engage dowel pins in the base plate. In molding the rings, the various parts are first assembled. The sleeve B is then removed and a weighed amount of the prepared ring mix is placed in the space between the parts A and C, care being taken to spread the mix as uniformly as possible. Experiment will be necessary to determine the weight of clay mix necessary to give the proper sized ring. The sleeve B is then replaced and subjected to a downward pressure of approximately 700 lb. per sq. in. The mold is then removed from the press and inverted upon a solid support. The base plate is next taken off and the ring then ejected by pressure upon the parts A and C. The ring after removal is dried and burned to 1350 deg. C. (2462 deg. F.).

The rings shall be 2½ in. in inside diameter, and ½ in. deep, and with walls ½ in. thick. The rings shall be made of well-burned clay and shall be cemented on the brick with a refractory cement.[1] The brick surface enclosed within the ring shall be free from all foreign material.

For general use a synthetic slag[2] shall be used as a solvent. This slag shall be ground until it will pass a 40-mesh sieve.

The brick shall be placed level on the hearth of a cold furnace and heated to 1350 deg. C. (2462 deg. F.), attaining this temperature in a time not less than 5 hours. Thirty-five grams of powdered slag shall then be introduced by a metal spoon or equivalent device, avoiding scattering it upon the sides of the ring. The temperature shall then be held as nearly as possible at 1350 deg. C. (2462 deg. F.), for 2 hours; the fluctuations should not exceed 10 deg. C. (18 deg. F.) above or below this point. The furnace shall then be allowed to cool without removing the brick. An oxidizing condition shall be maintained in the furnace thruout the test.

When cold, the brick shall be sawed so that one of the sawed surfaces accurately bisects the center of the rings, but it will be permissible to nick and break the brick,

---

[1] The mix used in cementing the rings on the brick is as follows:

46.5 per cent., by weight, of first-quality fire clay ground to pass a 100-mesh sieve;

46.5 per cent., by weight, of first-quality silica brick ground to pass a 100-mesh sieve;

7 per cent., by weight, of sodium silicate (Baume 50 deg.).

Sufficient water is added to the above mix to give a sirupy consistency.

The position the ring is to occupy on the brick is first marked by running a pencil around both the inner and outer circumferences of the ring when laid in position, thus outlining the surface of the brick touched by the ring. On this marked surface a coating of the above cement about 1/32 in. thick is applied with a brush and the ring firmly pressed into place with a circular or twisting motion, while the cement is still soft. If the surface of the brick is rough it may be necessary to coat the lower surface of the ring also before placing it upon the brick.

[2] For general use with this test, a synthetic slag has been developed of the following composition:

Silica (SiO_2)	19.00 per cent.
Alumina, (Al_2O_3)	12.89 per cent.
Iron Oxide (Fe_3O_4)	15.73 per cent.
Lime (CaO)	33.50 per cent.
Magnesia (MgO)	6.93 per cent.
Manganese (MnO)	3.52 per cent.
Sodium Oxide	8.50 per cent.
Melting Point of above slag	1270 deg. C.

The materials as weighed out to give a pound of melted slag are as follows:

Silica	72 grams
Alumina	58 grams
Ferric Oxide	80 grams
Calcium Carbonate	304 grams
Magnesium Oxide	39 grams
Manganese Dioxide	24 grams
Sodium Carbonate	66 grams

Any multiple of the above quantity may be used.

Ground silica brick is used as a source of silica. All other materials are c. p. chemicals. All materials should be sufficiently fine to pass a 40-mesh sieve and after being weighed out must be carefully and thoroly mixed. Melting is performed in a plumbago crucible at a temperature of approximately 1350 deg. C. (2462 deg. F.). The mix should be placed in the crucible before heating.

The slag when melted is poured into a suitable receptacle and cooled. After cooling, the slag is ground and is then ready for use.

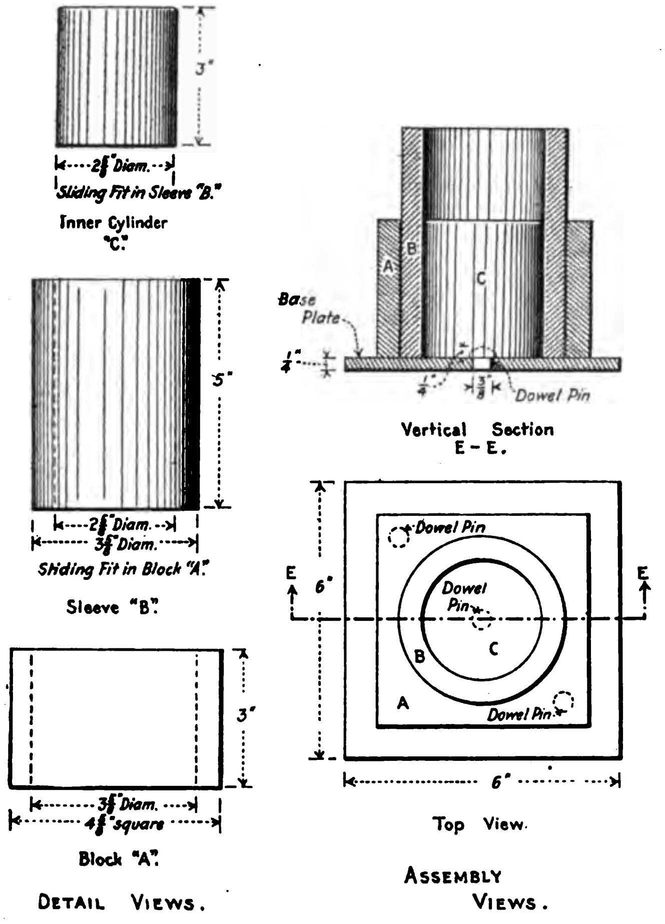


FIG. 1.—Mold for Molding Rings.

provided they are broken so that there is no greater variation than $\frac{1}{16}$ in.

The wheel used for sawing the brick is a silicon-carbide wheel, 12 in. in diameter, ½ in. thick, 1½ in. diameter of center hole, grit 16. This wheel is known as a vulcanite wheel.

532—ROPE, MANILA

Sizes of Snatch Blocks for Manila Rope

Length of Shell in Inches	For Rope of Inches, Diameter	Size of Sheave, Inches
6	⅞	3 x1⅛x ½
7	⅞	3½x1¼x ½
8	1	4½x1⅜x ⅝
9	1⅛	5 x1⅜x ⅝
10	1¼	5¾x1⅞x ¾
12	1½	6¾x2⅛x ¾
14	1¾	8 x2¼x ⅞
16	2	9 x2⅝x1
18	2¼	10 x3 x1⅛
20	2½	11 x3½x1¼
22	3	11¾x4¼x1½

Working Loads

For manila ropes from 1 to 1¾ ins. diam., running at different speeds over sheaves of the diams. stated, C. W. Hunt (Trans. Am. Soc. Mechl. Engrs., Vol. XXIII, 1901) gives a table embodying approximately the following results of experience. Working load = C multiplied by ultimate strength of new rope. D = minimum diam. of sheave, in ins.

Speed	Ft. per min.	As for work on	C	1" rope D	1¾" rope D
Slow	50 to 100	Derrick, crane, quarry	0.140	8	14
Medium	150 to 300	Wharf, cargo	0.056	12	18
Rapid	400 to 800		0.028	40	70

Such ropes wear out rapidly. A rope 1½ ins. diam. wears out in lifting from 7,000 to 10,000 tons of coal. On the other hand, 1½ in. transmission ropes, running 5,000 ft. per min. and carrying 1,000 H. P. over sheaves 5 ft. and 17 ft. in diam., last for years.

Mr. Hunt's figures for ultimate strength, based upon tests of full-sized specimens of manila rope made by three independent rope-walks and purchased in open market, are practically identical with those given in our table above, as are also those of Prof. B. Kirsch of the Imperial Royal Technological Industrial Museum, Vienna, quoted by Mr. Hunt.

See also Drive, rope.

533—ROPE, WIRE

Rope, Wire—for inclined Planes.

The following table gives the stress produced in a rope by a load of one ton of 2,000 pounds, an allowance for rolling friction being made. An additional allowance for the weight of the rope should be made.

Example.—For an inclination of 25 ft. in 100 ft., corresponding to an angle of 14° 02′, a load of 2,000 pounds, will produce a stress in the rope of 525 pounds, and for a load of 8,000 pounds the stress in the rope will be $\frac{525 \times 8{,}000}{2{,}000} = 2{,}100$ pounds.

Rise, per 100 Feet, Horizontal, Feet	Angle of Inclination	Stress, in Pounds, per Ton of 2,000 Pounds	Rise, per 100 Feet, Horizontal Feet	Angle of Inclination	Stress, in Pounds, per Ton of 2,000 Pounds
5	2°52′	140	105	46°24′	1484
10	5°43′	240	110	47°44′	1516
15	8°32′	336	115	48°59′	1545
20	11°19′	432	120	50°12′	1573
25	14°02′	525	125	51°20′	1597
30	16°42′	613	130	52°06′	1620
35	19°17′	700	135	53°28′	1642
40	21°48′	782	140	54°28′	1663
45	24°14′	860	145	55°24′	1682
50	26°34′	933	150	56°19′	1699
55	28°49′	1003	155	57°10′	1715
60	30°58′	1067	160	58°00′	1730
65	33°01′	1128	165	58°47′	1744
70	34°59′	1185	170	59°32′	1758
75	36°52′	1238	175	60°15′	1771
80	38°40′	1287	180	60°57′	1787
85	40°22′	1332	185	61°36′	1792
90	41°59′	1375	190	62°14′	1804
95	43°32′	1415	195	62°51′	1813
100	45°00′	1450	200	63°26′	1822

A factor of safety of five to seven times should be taken: that is, the working load on the rope should only be one-fifth to one-seventh of its breaking strength. As a rule, ropes for shafts should have a factor of safety of five, and on inclined planes, where the wear is much greater, the factor of safety should be seven.

26—BABBITT METAL

Analyses of Bearing-metal Alloys.

Metal.	Copper.	Tin.	Lead.	Zinc.	Antimony.	Iron.
Camelia metal	70.20	4.25	14.75	10.20	....	0.55
Anti-friction metal	1.60	98.13	....	....	....	trace
White metal	....	....	87.92	....	12.08	....
Car-brass lining	....	trace	84.87	....	15.10	....
Salgee anti-friction	4.01	9.91	1.15	85.57	....	....
Graphite bearing-metal	....	14.38	67.73	....	16.73	? (1)
Antimonial lead	....	....	80.69	....	18.83	....
Carbon bronze	75.47	9.72	14.57	....	....	....(2)
Cornish bronze	77.83	9.60	12.40	trace	....	trace(3)
Delta metal	92.39	2.37	5.10	....	....	0.07
* Magnolia metal	trace	....	83.55	trace	16.45	trace(4)
American anti-friction metal	....	....	78.44	0.98	19.60	0.65
Tobin bronze	59.00	2.16	0.31	38.40	....	0.11
Graney bronze	75.80	9.20	15.06	....	....	....
Damascus bronze	76.41	10.60	12.52	....	....	....
Manganese bronze	90.52	9.58	....	....	....	....(5)
Ajax metal	81.24	10.98	7.27	....	....	....(6)
Anti-friction metal	....	....	88.32	....	11.93	....
Harrington bronze	55.73	0.97	....	42.67	....	0.68
Car-box metal	....	....	84.33	trace	14.38	0.61
Hard lead	....	....	94.40	....	6.03	....
Phosphor-bronze	79.17	10.22	9.61	....	....	....(7)
Ex. B. metal	76.80	8.00	15.00	....	....	....(8)

Other constituents:

(1) No graphite.
(2) Possible trace of carbon.
(3) Trace of phosphorus.
(4) Possible trace of bismuth.
(5) No manganese.
(6) Phosphorus or arsenic, 0.37.
(7) Phosphorus, 0.94.
(8) Phosphorus, 0.20.

* Dr. H. C. Torrey says this analysis is erroneous and that Magnolia metal always contains tin.

562—SEWER PIPE

The Following Specifications and Tests Are Excerpts from the Standard Specifications Adopted by the American Society for Testing Materials for Clay Sewer Pipe.

Physical Tests

The physical tests of pipes shall include: Crushing test, hydrostatic pressure test, and absorption test.

(A) Crushing Tests

(a) Any prime mover or hand power which will apply the load at a uniform rate of about 2,000 lbs. per minute, or in increments of not more than 100 lbs. at the same rate, may be used in making the test.

(b) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(c) The testing machine shall be substantial and rigid thruout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part.

(d) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(e) The load shall be applied until the pipe yields by cracks passing thru the shell.

(See Fig. 1, below).—Except as otherwise hereinafter specified, the pipe to be tested shall be supported by a metallic knife bearing 1 in. wide and extended from a point just back of the socket to the spigot end of the pipe. Before the pipe is placed a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the pipe barrel, shall be cast on the surface of the knife-edge bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied thru an upper knife bearing of the same size and length as the lower bearing. A plaster of Paris fillet 1 in. wide shall be cast along the length of the crown of the pipe to equalize the lower bearing before the upper one is brought into contact.

Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads thruout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

At the option of the consumer or purchaser the crushing test may be applied with sand bearings or with two or three-edge bearings.

The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot; and by then multiplying the quotient by the following factors:

For knife or two-edge bearings..........10/7
For three-edge bearings................10/7
For Sand bearings....................1.00

(See Fig. 2, below).—When three-edge bearings are used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test.

The two lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately ½ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied thru the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a pipe which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

(See Fig. 3, below).—When sand bearings are used, the ends of each specimen of pipe shall be accurately marked prior to the test in quarters of the circumference. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest

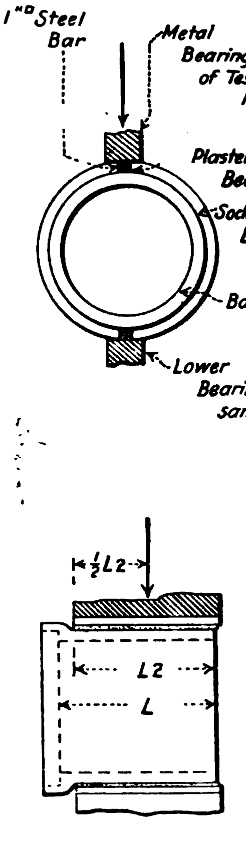


FIG. 1.—Knife or Two-Edge Bearings.

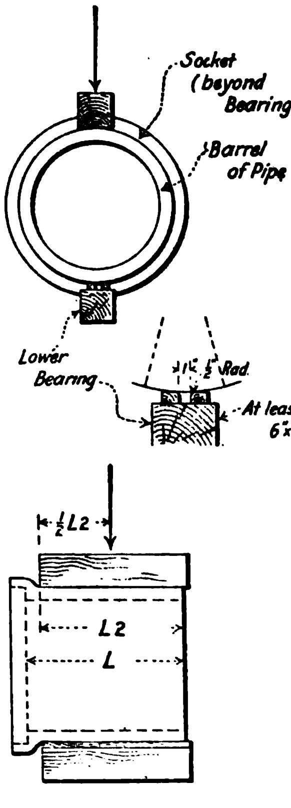


FIG. 2.—Three-Edge Bearings.

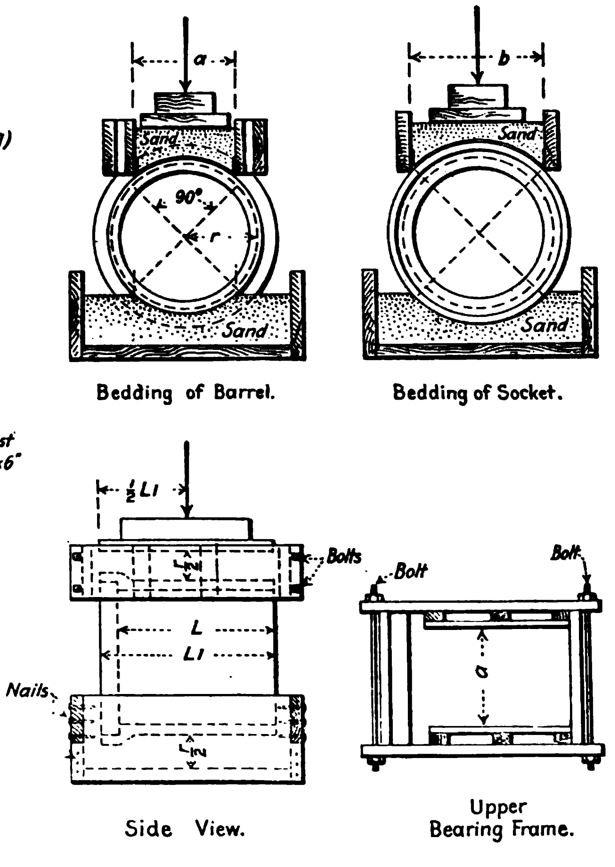


FIG. 3.—Sand Bearings.

points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come into contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line thru the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come into contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

The crushing test shall ordinarily be applied to not less than 75 per cent of the specimens received for testing purposes.

Pieces of the crushed pipe may be used as specimens in making the absorption test.

(B) Hydrostatic Test

Sound full-size pipe not exceeding about 25 per cent. of the specimens received for test in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur thru the covers at the test pressure. One cover shall be provided with a ¾-in. wrought-iron nipple passing thru the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

Water pressure, as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen as follows:

5 lbs. per sq. in. for 5 minutes.
10 lbs. per sq. in. for 10 minutes.
15 lbs. per sq. in. for 15 minutes.

The specimens shall show no leakage under these pressures. Moisture appearing on the surface of the pipe in the form of patches or beads, adhering to the surface, shall not be considered leakage.

(C) Absorption Test

The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing or other tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110 deg. C. (230 deg. F.) for not less than three hours. After removal from the dryer, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25 deg. C. (68 to 77 deg. F.), and then reweighed.

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest gram. When other than metric weights are used, the same degree of accuracy shall be obtained.

The specimen, after final drying, cooling and weighing, shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15 deg. C. (50 to 59 deg. F.).

The specimen shall be allowed to drain for one minute, and the superficial moisture having been removed by towel or blotting paper, placed upon the balance.

The test result shall be calculated as percentage of the initial dry weight.

One specimen shall be tested of each pipe broken in the crushing test.

The results shall be reported separately for each individual specimen, together with the mean for all the specimens from the same shipment of pipe.

Each specimen shall be marked so that it may be identified with the pipe used in the crushing test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent. of the total superficial area of the specimen.

Physical Test Requirements

The test requirements of clay sewer pipe shall be as given in Table I. The individual results of the various tests for each size of pipe and for each shipment class and mill shall be tabulated separately so as to show the percentage which fails to comply with the requirements of each test.

Table I.—Physical Test Requirements of Clay Sewer Pipe

Internal Diameter, In.	Minimum Crushing Strength[1], Lb. per Lin. Ft.	Maximum Absorption, per cent.
4	1430	8
6	1430	8
8	1430	8
10	1570	8
12	1710	8
15	1960	8
18	2200	8
21	2590	8
24	3070	8
27	3370	8
30	3690	8
33	3930	8
36	4400	8
39	4710	8
42	5030	8

[1] See Crushing tests on page 194.

263—FIRE BRICK

TABLE OF 9-INCH ARCH BRICK

Inside Diameter	Shapes Required				
	No. 3 Arch	No. 2 Arch	No. 1 Arch	Straight	Total
0 ft 6 in.	19	....	....	....	19
1 " 0 "	12	15	....	....	27
1 " 6 "	4	30	....	....	34
1 " 9 "	....	38	....	....	38
2 " 0 "	....	34	8	....	42
2 " 6 "	....	26	23	....	49
3 " 0 "	....	19	38	....	57
3 " 6 "	....	11	53	....	64
4 " 0 "	....	4	68	....	72
4 " 3 "	....	....	76	....	76
4 " 6 "	....	....	76	4	80
5 " 0 "	....	....	76	11	87
5 " 6 "	....	....	76	19	95
6 " 0 "	....	....	76	27	103
6 " 6 "	....	....	76	34	110
7 " 0 "	....	....	76	42	118
7 " 6 "	....	....	76	49	125
8 " 0 "	....	....	76	57	133
8 " 6 "	....	....	76	64	140
9 " 0 "	....	....	76	72	148
9 " 6 "	....	....	76	79	155
10 " 0 "	....	....	76	87	163
10 " 6 "	....	....	76	94	170
11 " 0 "	....	....	76	102	178
11 " 6 "	....	....	76	109	185
12 " 0 "	....	....	76	117	193

575—SIEVE, TESTING

This screen scale has as its base an opening of .0029-inch which is the opening in 200 mesh .0021-inch wire, the standard sieve, as adopted by the Bureau of Standards of the United States Government, the openings increasing in the ratio of the square root of 2 or 1.414.

Where a closer sizing is required in the finer openings, a scale is shown below this table from 65 to 200 mesh, in which the openings increase in the ratio of the fourth root of 2 or 1.189.

Opening in Inches, Ratio $\sqrt{2}$ or 1.414	Opening in Millimeters	Mesh	Diameter Wire Decimal of an Inch
1.050	26.67		.149
.742	18.85		.135
.525	13.33		.105
.371	9.423		.092
.263	6.680	3	.070
.185	4.699	4	.065
.131	3.327	6	.036
.093	2.362	8	.032
.065	1.651	10	.035
.046	1.168	14	.025
.0328	.833	20	.0172
.0232	.589	28	.0125
.0164	.417	35	.0122
.0116	.295	48	.0092
.0082	.208	65	.0072
.0058	.147	100	.0042
.0041	.104	150	.0026
.0029	.074	200	.0021

For Closer Sizing—65 to 200 Mesh

Opening in Inches, Ratio $\sqrt[4]{2}$ or 1.189	Opening in Millimeters	Mesh	Diameter of Wire, Decimal of an Inch
.0082	.208	65	.0072
.0069	.175	80	.0056
.0058	.147	100	.0042
.0049	.124	115	.0038
.0041	.104	150	.0026
.0035	.088	170	.0024
.0029	.074	200	.0021

Testing Sieves for Fine Grinding

Opening in Inches	Opening in Millimeters	Mesh	Diameter of Wire, Decimal of an Inch
.0340	.864	20	.016
.0198	.503	30	.0135
.0176	.447	35	.011
.0150	.381	40	.010
.0127	.323	45	.0095
.0110	.279	50	.009
.0087	.221	60	.008
.0073	.185	70	.007
.0068	.173	80	.00575
.0059	.150	90	.00525
.0055	.140	100	.0045
.0051	.130	110	.004
.0046	.117	120	.0037
.0043	.109	130	.0034
.0042	.107	140	.0029
.0041	.104	150	.0026
.0038	.096	160	.0025
.0035	.089	170	.0024
.0033	.084	180	.0023
.0031	.079	190	.0022
.0029	.074	200	.0021
.0028	.071	220	.0017
.0026	.066	240	.0016

Courtesy of W. S. Tyler Co.

605—STEEL

To Distinguish Steel from Wrought Iron

In the process of steel manufacture, manganese has to be added to the molten metal in order to make it possible to roll and weld it into pipe, while wrought iron requires no such manganese addition and therefore usually contains only a trace of this metal. To test for manganese place in a porcelain dish, preferably a small porcelain crucible, a clean, bright drill chip or some filings of the metal to be tested, about the size of a pinhead; add six drops of pure nitric acid, heat, add two drops of silver nitrate solution, then one crystal of ammonium persulphate not greater than one-eighth inch in diameter. Warm the solution, but do not let it boil. If the metal is steel, a pink color will begin to develop and at this point it should be removed from the source of heat, when a very decided red coloration will result. If no coloration develops, but a small amount of dark residue remains in the dish, the metal is wrought iron.

Care should be taken at all times to test only clean samples and to keep dirt or foreign matter out of the dish. If a thimble-size crucible is used, a match will supply sufficient heat for the purpose.

604—STEAM TRAPS

The following method is used to determine whether or not a steam trap leaks steam:

A. Weight of bucket and water........... = 14.75 lbs.
B. Weight of bucket..................... = 2 lbs.
C. Weight of water, net, before test, A—B... = 12.75 lbs.
D. Temperature of room.................. = 80° F.
E. Temperature of water before test....... = 60° F.
F. Difference between temperature of room and water, D — E..................... = 20° F.
G. Temperature to which water in bucket should be raised, D + F (approximately). (As much above room temperature as it was below room temperature at start)..... = 100° F.
H. Time at beginning of test............. =
I. Actual temperature of water at end of test = 109° F.
J. Weight of bucket and water after test... = 17.5 lbs.
K. Weight of bucket (B)................ = 2 lbs.
L. Weight of water, net, after test, J — K... = 15.5 lbs.
M. Amount of heat, B.t.u.'s, in water at end of test, L × (I — 32°)................. = 1193
N. Amount of heat, B.t.u.'s, in water at start of test, C × (E — 32°)................ = 357
O. Amount of heat, B.t.u.'s, put into water by trap discharge, M — N............... = 836
P. Amount of water or water and steam added during test, L — C................ = 2.75 lbs.
Q. Steam-gauge pressure (average) at trap during test......................... = 95 lbs.
R. Heat of the liquid or number of heat units (B.t.u.'s) in a pound of water discharged from the trap at above steam pressure (Q) .... = 305.5
S. Total heat of liquid or B.t.u.'s in water discharged from trap, R × P........... = 840
T. Time at finish of test............... =

Conclusion: As the number of B.t.u.'s brought in by water checks closely with the number actually found, see O and S, there could have been no steam-leakage, as even 1-10th of a pound of steam would have brought in about 100 additional heat units. This shows how accurately even a small quantity of steam could be detected.

NOTE: It is absolutely essential that accurate scales are used for weighing the water and accurate weights obtained and tabulated.

Courtesy Johns-Manville, Inc.

134—CLAY WINNING

Table for Working Plane of Gravity Incline or Self-Acting Systems

No. of Cars	Wt. of Cars Descending Pounds	Wt. of Cars Ascending Pounds	Length of Rope Feet	Rise in 100 ft. necessary to make plane self-acting Feet	Strain In Rope Pounds
1	4,000	1,400	500	5.5	135
1	4,000	1,400	1,000	6.3	174
1	4,000	1,400	1,500	8.2	240
1	4,000	1,400	2,000	10.0	318
2	8,000	2,800	500	5.0	231
2	8,000	2,800	1,000	5.5	270
2	8,000	2,800	1,500	6.1	314
2	8,000	2,800	2,000	6.7	364
4	16,000	5,600	500	4.8	412
4	16,000	5,600	1,000	5.0	463
4	16,000	5,600	1,500	5.2	497
4	16,000	5,600	2,000	5.5	539

(The above is for ⅝-inch steel rope.)

No. of Cars	Angle of Inclination Degrees	Rise in 100 Ft. Feet	Wt. of Car Descending Lbs.	Wt. of Car Ascending Lbs.	Strain in Rope Lbs.	Diam. of Rope Inch
1	5	8.7	4,000	1,400	300	5/8
1	45	100.0	4,000	1,400	3,000	11/16
4	45	100.0	16,000	5,600	11,916	1¼

148—CONES, PYROMETRIC

FUSING POINTS OF SEGER CONES

Number of Cone	Fusing Point Original Scale		Number of Cone	Fusing Point Original Scale		Revised Scale	
	Degrees Fahr	Degrees Centig.		Degrees Fahr	Degrees Centig.	Degrees Fahr.	Degrees Centig.
.022	1,094	590	10	2,426	1,330		
.021	1,148	620	11	2,462	1,350		
.020	1,202	650	12	2,498	1,370		
.019	1,256	680	13	2,534	1,390		
.018	1,310	710	14	2,570	1,410		
.017	1,364	740	15	2,606	1,430		
.016	1,418	770	16	2,642	1,450		
.015	1,472	800	17	2,678	1,470		
.014	1,526	830	18	2,714	1,490	2,714	1,490
.013	1,580	860	19	2,750	1,510	2,750	1,510
.012	1,634	890	20	2,786	1,530	2,786	1,530
.011	1,688	920	21†	2,822	1,550		
.010	1,742	950	22†	2,858	1,570		
.09	1,778	970	23†	2,894	1,590		
.08	1,814	990	24†	2,930	1,610		
.07	1,850	1,010	25†	2,966	1,630		
.06	1,886	1,030	26	3,002	1,650	2,912	1,600
.05	1,922	1,050	27	3,038	1,670	2,948	1,620
.04	1,958	1,070	28	3,074	1,690	2,975	1,635
.03	1,994	1,090	79	3,110	1,710	3,002	1,650
.02	2,030	1,110	30	3,146	1,730	3,038	1,670
.01	2,066	1,130	31	3,182	1,750	3,065	1,685
1	2,102	1,150	32	3,218	1,770	3,101	1,705
2	2,138	1,170	33	3,254	1,790	3,128	1,720
3	2,174	1,190	34	3,290	1,810	3,164	1,740
4	2,210	1,210	35	3,326	1,830	3,191	1,755
5	2,246	1,230	36	3,362	1,850		
6	2,282	1,250	37	3,398	1,870		
7	2,318	1,270	38	3,434	1,890		
8	2,354	1,290	39	3,470	1,910		
9	2,390	1,310					

*U. S. Bureau of Standards, Washington, D. C.

†Cones 21 to 25 inclusive, all come down at practically the same temperature.

MACHINE SHOP EQUIPMENT

Horsepower Required for Driving Machine Tools

Machine	Motor Used
90 inch lathe	25 H.P. Shunt Wound Variable Speed
72 inch lathe	25 H.P. Shunt Wound Variable Speed
42 inch lathe	15 H.P. Shunt Wound Variable Speed
30 inch lathe	10 H.P. Shunt Wound Variable Speed
Axle lathe	35 H.P. Shunt Wound Variable Speed
72 inch boring lathe	25 H.P. Shunt Wound Variable Speed
60 inch planer	20 H.P. Compound Wound Variable Speed
42 inch planer	15 H.P. Compound Wound Variable Speed
19 inch slotter	13 H.P. Compound Wound Variable Speed

This data compiled from actual tests run by the P. & L. E. R. R. Co.

The Electric World According to Kent Published the Following as the Power Needed in Each Case:

Boring Mills	H.P.
34 and 36 inch	5
42, 48 and 50 inch	7½
60 inch	10
6 ft. and 7 ft.	15
8 ft.	20
10 ft.	25

Shapers	H.P.
12 to 16 inch	2
18 to 20 inch	3
24 to 26 inch	5
28 to 30 inch	6
36 inch	8

Engine Lathes	H.P.
12 and 14 inch	1
16 inch	1½
20 to 25 inch	2
20 and 30 inch	3
36 inch	4
42 and 48 inch	5
54 inch	6
60 inch	7½
72 inch	10

Drill Presses	H.P.
21 to 32 inch	2
36 to 48 inch	3
50 to 60 inch	5

Slotters	H.P.
12 to 14 inch	5
16 and 18 inch	7½
26 to 36 inch	10

Planers	H.P.
17 x 17 inch x 3 to 6 ft.	4
22 x 24 inch x 4 to 10 ft.	5
26 x 26 inch x 6 to 12 ft.	6
30 x 30 inch x 6 to 14 ft.	7½
36 x 36 inch x 8 to 16 ft.	7½
42 x 42 inch x 10 to 12 ft.	10
48 x 48 inch x 12 to 14 ft.	15
50 x 60 inch x 14 to 18 ft.	20
60 x 60 inch x 20 to 22 ft.	25
72 x 72 inch x 20 to 24 ft.	30

62—BOILER TUBES

External Diameter, Ins.	Internal Diameter, Ins.	Internal Circumference, Ins.	External Circumference, Ins.	Length of Tube in Ft. per Sq. Ft. Inside Surface	Length of Tube in Ft. per Sq. Ft. Outside Surface	Weight per Lineal Ft.
1	0.810	2.545	3.142	4.479	3.820	0.90
1¼	1.060	3.330	3.927	3.604	3.056	1.15
1½	1.310	4.115	4.712	2.916	2.547	1.40
1¾	1.560	4.901	5.498	2.448	2.183	1.65
2	1.810	5.686	6.283	2.110	1.910	1.91
2¼	2.060	6.472	7.069	1.854	1.698	2.16
2½	2.282	7.169	7.854	1.674	1.528	2.75
2¾	2.532	7.955	8.639	1.508	1.389	3.04
3	2.782	8.740	9.425	1.373	1.273	3.33
3¼	3.010	9.456	10.210	1.269	1.175	3.96
3½	3.260	10.242	10.996	1.172	1.091	4.28
3¾	3.510	11.027	11.781	1.088	1.019	4.60
4	3.732	11.724	12.566	1.024	0.955	5.47
4½	4.232	13.295	14.137	0.903	.849	6.17
5	4.704	14.778	15.708	.812	.764	7.58
6	5.670	17.813	18.850	.674	.637	10.16
7	6.670	20.954	21.991	.573	.546	11.90
8	7.670	24.096	25.133	.498	.477	13.65
9	8.640	27.143	28.274	.442	.424	16.76
10	9.594	30.141	31.416	.398	.382	21.00

To ascertain the safe working pressure on a boiler, multiply twice the thickness of the shell by the tensile strength, and divide the product by the diameter of the shell in inches.

258—FELDSPAR

Composition of Important Pure Feldspars

Trade Names	Potash Feldspars	Soda Feldspars	Lime Feldspars
Mineralogical Names	Orthoclase and Microcline	Albite	Anorthite
Chemical Formulas	K Al Si_3O_8 or K_2O Al_2O_3 $6SiO_2$	Na Al Si_3O_8 or Na_2O Al_2O_3 $6SiO_2$	Ca Al_2 Si_2O_8 or CaO Al_2O_3 $2SiO_2$

Percentage Composition

Silica SiO_2	64.7	68.8	43.3
Alumina Al_2O_3	18.4	19.4	36.6
Potassium Oxide K_2O	16.9	....	....
Sodium Oxide Na_2O	....	11.8	....
Calcium Oxide CaO	....	....	20.1

Analyses of Commercial Ground Feldspars

Silica (SiO_2)	76.37	65.87	65.73	69.05	69.45	65.50	68.20	71.07
Alumina (Al_2O_3)	13.87 (a)	19.10 (a)	19.28 (a)	17.40	16.76	21.17	18.17	16.23
Ferric Oxide (Fe_2O_3)				.15	0.20	0.18	.66	0.53
Lime (CaO)	.26	.20	.22	.12	0.45	0.87	.38	0.43
Magnesia (MgO)	.00				0.45	1.40	.26	0.24
Potash (K_2O)	5.24	12.24	10.26	10.03	9.80	8.98	10.18	8.24
Soda (Na_2O)	3.74	2.56	4.08	2.97	2.60	1.00	2.60	2.98
Loss on Ignition	0.30	0.64	0.48		.28	0.15	.59	.39

(a) Including small amounts of iron oxide.

The substitutes for feldspar that are used chiefly are Cornwall or Cornish stone, mica and talc. These materials are described under separate items in the definition section.

96—CAR LOADERS

The attached table was made up for loading fire brick, measuring 2½x4½x9 inches, and weighing six and one-tenth pounds, so that the brick in one or both ends of the car will be not more than one brick higher than the brick in the center of the car. The capacities of the cars in every case were taken at ten per cent. more than the marked capacity.

TABLE FOR LOADING FOREMAN

Inside Length Feet	No. of Brick Wide	Cap. Tons	End of Car No. of Rows	End of Car No. of Brick High	Center No. of Rows	Center No. of Brick High
34	37	30	25	7	19	6
		40	36	9	8	8
		50	44	11	0	—
	38	30	17	7	27	6
		40	26	9	18	8
		50	31	11	13	10
	39	30	10	7	34	6
		40	16	9	28	8
		50	19	11	25	10
	40	30	3	7	41	6
		40	7	9	37	8
		50	7	11	37	10
36	37	30	7	7	40	6
		40	12	9	35	8
		50	14	11	33	10
	38	30	47	6	0	—
		40	2	9	45	8
		50	47	10	0	—
	39	30	39	6	8	5
		40	39	8	8	7
		50	36	10	11	9
	40	30	33	6	14	5
		40	30	8	17	7
		50	25	10	22	9
38	37	30	39	6	11	5
		40	38	8	12	7
		50	34	10	16	9
	38	30	32	6	18	5
		40	28	8	22	7
		50	21	10	29	9
	39	30	24	6	26	5
		40	18	8	32	7
		50	9	10	41	9
	40	30	18	6	32	5
		40	9	8	41	7
		50	50	9	0	—
40	37	30	24	6	29	5
		40	17	8	36	7
		50	7	10	46	9
	38	30	17	6	36	5
		40	7	8	46	7
		50	47	9	6	8
	39	30	9	6	44	5
		40	50	7	3	6
		50	35	9	18	8
	40	30	3	6	50	5
		40	41	7	12	6
		50	24	9	29	8

The following method has been used in figuring this table. The number of rows of brick in the car has been multiplied by the number of brick in width. This result has been divided into the number of brick to be loaded. In every case the result is a quotient and a remainder. The quotient shows the number of brick in height at which the center of the car is to be loaded. The answer received by dividing the number of brick in width, into the remainder spoken of above, will show the number of rows that must be loaded one higher than the center of the car. For example, suppose we have a thirty-six foot car of forty-ton capacity and it will take thirty-nine brick across.

39 brick × 47 rows = 1,833
14,350 brick × 6.1 pounds = 87,535
14,350 brick ÷ 1833 = 7

times with a remainder of 1,519. This means that the center of the car must be seven brick high and that enough rows must be eight high on the ends to add 1,519 brick; 1,519 divided by 39 gives 39 rows. In other words, with a brick weighing 6.1 pounds and a car of these dimensions, if thirty-nine rows are loaded eight high and the remaining eight rows seven high, the car will contain a few brick more or less than 14,350. By this method it is easy to make a table for brick of any average weight. Moreover cars of odd sizes or capacity not found on this table can easily be figured.

Fire brick or silica brick shapes can be loaded by this same method, but allowance must be made whenever a shape is oddly shaped enough to take up more space than solid brick. The car can be loaded five per cent., ten per cent., or even twenty-five per cent. higher.

214—DRUM, WINDING

Smallest Diameter in Feet of Drum or Sheave

Diameter of Rope in Inches	STEEL ROPES 19 Wires to the Strand Feet	STEEL ROPES 7 Wires to the Strand Feet	IRON ROPES 19 Wires to the Strand Feet	IRON ROPES 7 Wires to the Strand Feet
2¼	8.6	....	13	....
1½	5.7	8.6	7.9	13
1	4.0	5.7	5.4	8.6
½	1.5	2.6	2.3	4.0

Working load being one-fifth of the ultimate strength.

The Following Strengths and Diameters are Advisable:

Diameters of Wire Rope, in Inches	Maximum Working Load, Pounds	Drum Diameters, in Inches One Layer of Rope	Two Layers of Rope	Three Layers of Rope	Four Layers of Rope	Five Layers of Rope
½	4,050	11½	15¼	22½	29½	36½
⅝	6,300	14½	19	27¾	36½	45½
¾	8,750	17	23	32	42¼	51½
⅞	11,650	20	25	36½	48	59

The surface of the drum should be grooved to fit the first layer of cable.

From Roebling Sons Co.

57—BOILER

Horse Power Capacity

Kent says that if a boiler horse power is taken to mean the evaporation of 34.5 lbs. of water from and at 212 deg. F., the average proportions of the various parts per horse power for maximum economy for land boilers fired with good anthracite coal are as follows:

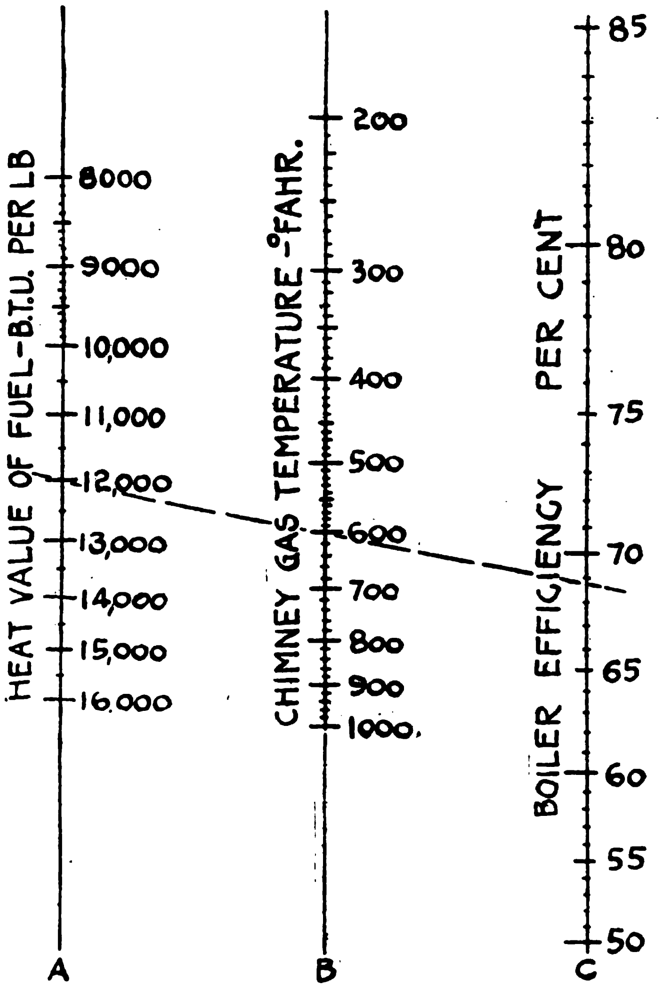


Chart to Show Boiler Efficiency

Heating surface ....11.5 sq. ft.
Grate surface ....1/3 sq. ft.
Ratio of heating to grate surface...34.5 sq. ft.
Water evaporated from and at 212 deg.
F. per sq. ft. heating surface per hour. 3 lbs.
Combustible burned per h. p. per hour.. 3 lbs.
Combustible burned per sq. ft. grate
surface per hour.................... 9 lbs.
Water evaporated from and at 212 deg.
F. per lb. combustible............11.5 lbs.

To Obtain Approximate Boiler Efficiency

The accompanying chart gives approximate boiler efficiency and at the same time gives an idea of the benefits to be derived from keeping the temperature of the stack gases as low as possible. The diagonal line is drawn for a case where the heat value of the fuel equalled a coal of 12,000 B. t. u. per pound, and the temperature of the gases going into the stack was 600 deg. F. The resulting efficiency amounts to 68.8 per cent.

210B—DRILL PRESS

To Find the Speed at Which a Drill Should Be Fed

Constant=12÷(size of drill x 3.1416).
Number of revolutions=constant x speed in feet.
Speed in feet=number of revolutions÷constant.

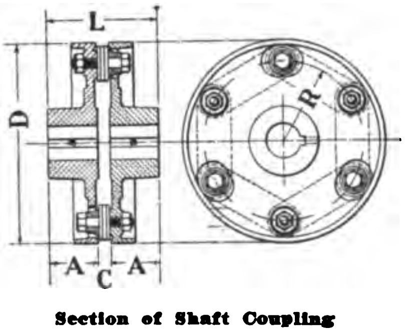
Size of Drill in Inches	Constant in Inches	Size of Drill in Inches	Constant in Inches	Size of Drill in Inches	Constant in Inches	Size of Drill in Inches	Constant in Inches
1/8	30.55	15/16	4.07	1 3/4	2.18	2 9/16	1.49
3/16	20.38	1	3.82	1 13/16	2.11	2 5/8	1.45
1/4	15.28	1 1/16	3.59	1 7/8	2.04	2 11/16	1.42
5/16	12.22	1 1/8	3.39	1 15/16	1.97	2 3/4	1.39
3/8	10.19	1 3/16	3.22	2	1.91	2 13/16	1.36
7/16	8.73	1 1/4	3.06	2 1/16	1.85	2 7/8	1.33
1/2	7.64	1 5/16	2.91	2 1/8	1.80	2 15/16	1.30
9/16	6.79	1 3/8	2.78	2 3/16	1.75	3	1.27
5/8	6.11	1 7/16	2.66	2 1/4	1.70	3 1/16	1.25
11/16	5.56	1 1/2	2.55	2 5/16	1.65	3 1/8	1.22
3/4	5.09	1 9/16	2.44	2 3/8	1.61	3 1/4	1.18
13/16	4.70	1 5/8	2.35	2 7/16	1.57		
7/8	4.36	1 11/16	2.26	2 1/2	1.53		

From Kent.

163—COUPLING, SHAFT

Size of Standard Flexible Couplings.

Pat. No.	H.P. at 100 RPM	Bore In Inches		Revoltn. Per Min.		Dia. D.	Rad. R.	Dia. of Std. Hub	Standard Hub		
		Std.	Max.	Max. for Std. Cplg.	Limit	Ins.	Ins.	Ins.	L. Ins.	A. Ins.	C. Ins.
1	2	1 3/16	1 11/16	2600	5000	7 1/2	2 5/8	3	5 1/4	1 15/16	1 3/8
2	6	1 11/16	2 11/16	1900	3600	11	4	4	6 1/2	2 9/16	1 3/8
3	10	1 15/16	3 15/16	1300	2400	16	6	4 3/8	7 1/2	3 1/16	1 3/8
4	15	2 3/16	5 7/16	1000	1900	20	8	5 1/4	9	3 15/16	1 3/8
5	30	2 15/16	7 1/2	800	1500	25	10	6 1/4	11 1/4	4 7/16	2 3/8
6	50	3 7/16	9	700	1300	29	12	7	12 3/4	5 5/16	2 3/8
7	100	4 7/16	11	600	1100	34	13 3/4	8 3/4	17	7 1/8	2 3/4
8	200	5 7/16	12	500	950	40	16	10 1/2	20	8 7/16	3 1/8
9	300	6 1/2	13	400	750	48	19 1/2	12 1/2	23 1/2	9 5/16	4 3/8



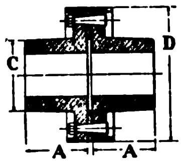
Section of Shaft Coupling

Size of Ring Couplings

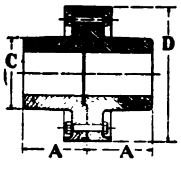
Size, Inches	Dimensions						
	Pat. No.	A	C	D	Thickness of Ring	No. Bolts	Dia. Bolts
1 11/16 to 1 15/16	30	3 1/2	4 3/8	9	1/2	4	5/8
2 3/16 to 2 7/16	40	4 3/8	5 1/4	10 1/2	1/2	4	3/4
2 11/16 to 2 15/16	50	5 1/4	6 1/8	11 1/2	1/2	4	3/4
3 3/16 to 3 7/16	60	6 1/8	7 1/4	13	1/2	6	3/4
3 11/16 to 3 15/16	70	7	7 3/4	14	3/4	6	7/8
4 3/16 to 4 7/16	80	7 7/8	8 1/2	15	3/4	6	1
4 11/16 to 4 15/16	90	8 3/4	9 1/2	16 1/4	3/4	6	1
5 3/16 to 5 7/16	100	9 5/8	10 1/8	17 1/2	3/4	6	1
5 15/16 to 6 1/4	110	11	11 3/4	19	1	6	1 1/8
6 1/2	120	11 3/8	11 7/8	20	1	7	1 1/8
7	130	12 1/4	12 5/8	21	1	8	1 1/8
7 1/2	140	13 1/8	13 1/2	22	1	8	1 1/8
8	150	13 1/8	14 1/4	24	1 1/4	8	1 1/8
9	160	13 1/2	16	26	1 1/4	8	1 1/4
10	170	14	18	30 3/4	1 1/4	8	1 1/2
12	180	15	20 1/4	33	1 1/4	10	1 1/2

Size of Flanged Face Couplings.

Size	Dimensions						
	Pat. No.	A	C	D	No. Bolts	Dia. Bolts	Lgth. of Bolts
1 3/16 to 1 7/16	20	2 5/8	3 5/8	7 1/2	4	1/2	1 3/4
1 11/16 to 1 15/16	30	3 1/2	4 3/8	9	4	5/8	2 1/2
2 3/16 to 2 7/16	40	4 3/8	5 1/4	10 1/2	4	3/4	2 3/4
2 11/16 to 2 15/16	50	5 1/4	6 1/8	11 1/2	4	3/4	3
3 3/16 to 3 7/16	60	6 1/8	7 1/4	13	6	3/4	3 1/4
3 11/16 to 3 15/16	70	7	7 3/4	14	6	7/8	3 3/4
4 3/16 to 4 7/16	80	7 7/8	8 1/2	15	6	1	4 1/4
4 11/16 to 4 15/16	90	8 3/4	9 1/2	16 1/4	6	1	4 1/2
5 3/16 to 5 7/16	100	9 5/8	10 1/8	17 1/2	6	1	4 3/4
5 15/16 to 6 1/4	110	11	11 1/4	19	6	1 1/8	5 1/4
6 1/2	120	11 3/8	11 7/8	20	7	1 1/8	5 1/2
7	130	12 1/4	12 5/8	21	8	1 1/8	5 3/4
7 1/2	140	13 1/8	13 1/2	22	8	1 1/8	6 1/4
8	150	13 1/8	14 1/4	24	8	1 1/8	6 1/2
9	160	13 1/2	16	26	8	1 1/4	6 1/2
10	170	14	18	30 3/4	8	1 1/2	8
12	180	15	20 1/4	33	10	1 1/2	8



Ring Coupling



Flanged Face Coupling

Clamp or Compression Coupling

Size	Outside Diameter	Length	Bolts		Pattern No.
			Number	Size	
1 11/16	4 1/2	7	6	1/2x2 3/4	1
1 15/16	4 3/4	8	6	1/2x2 3/4	2
2 3/16	5 3/4	10	6	5/8x3 1/4	3
2 7/16	6	11	6	5/8x3 1/4	4
2 11/16	7	11	6	3/4x4	5
2 15/16	7 1/4	12	6	3/4x4	6
3 3/16	8	13	6	7/8x4 1/2	7
3 7/16	8 1/4	13	6	7/8x4 1/2	8
3 11/16	8 3/4	14	6	7/8x5	9
3 15/16	9	14	6	7/8x5	10
4 3/16 to 4 7/16	10 1/2	16	6	1 x6	11
4 11/16 to 4 15/16	11	18	8	1 x6 1/2	12
5 7/16	12	20	8	1 x6 1/2	13
6	12 1/2	22	8	1 1/8x6 1/2	14

Courtesy Allis Chalmers Co.

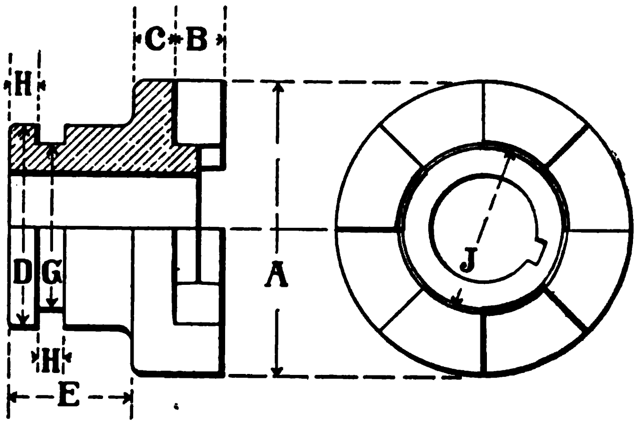
114—CHAIN BLOCK

A man cannot pull more than his own weight on the operating chains, and can pull faster in proportion as the pull required is lighter. The maximum pull usually required of one man is 82 lbs. and he will do more work with less fatigue if the hand chain pull is not over 40 lbs., because he can then pull the chain hand over hand a little more than twice as fast as he could when pulling twice as hard. When the hand chain pull is less than 20 lbs. the speed of hoisting an equal load is diminished because the man is tired by moving his arms too rapidly and cannot do as much work as with a heavier pull. The best result is obtained by using a chain block which has a capacity of double the usual load. The operator then works to the best advantage with average loads, and occasional heavy loads are easily handled without overstraining either the operator or the chain block, which should never be used beyond its capacity for fear of stretching the chain so that it will not work smoothly.

138—CLUTCH

Plain and Spiral Jaw Clutch Coupling

Size	No. of Jaws	Dimensions in Inches								Space on shaft when disengaged
		A	B	C	D	E	G	H	J	
1 7/16	3	3 3/4	7/8	9/16	3 1/4	2	2 3/8	5/8	2 1/4	7 1/8
1 11/16	3	4 1/4	1	5/8	3 1/2	2 1/4	2 1/2	5/8	2 1/2	8
1 15/16	3	4 3/4	1	5/8	4	2 1/2	3	5/8	2 3/4	8 1/2
2 3/16 to 2 7/16	3	6	1 1/4	3/4	4 3/4	2 3/4	3 1/2	3/4	3 1/2	9 3/4
2 11/16 to 2 15/16	3	7 1/4	1 1/2	1	5 1/2	3 1/4	4 1/4	3/4	4 1/4	11 3/4
3 3/16 to 3 7/16	4	8 1/2	1 1/2	1 1/8	6	3 3/4	4 3/4	7/8	5	13
3 11/16 to 3 15/16	4	9 3/4	1 3/4	1 1/4	6 3/4	4 1/4	5 1/2	7/8	5 3/4	14 3/4
4 3/16 to 4 7/16	4	11	2	1 1/2	7 1/2	4 1/2	6 1/4	1	6 1/2	16 1/4
4 11/16 to 4 15/16	4	12	2	1 5/8	8 1/4	5	6 3/4	1 1/8	6 3/4	17 1/2
5 7/16	4	13 1/4	2 1/4	1 3/4	9	5 1/4	7 1/2	1 1/8	7 1/4	18 3/4
5 15/16	6	14 1/2	2 1/2	2	10	6	8 1/4	1 1/4	8	21 1/4
6	6	15 1/2	2 1/2	2 1/8	10 1/2	6 1/4	8 3/4	1 1/4	8 1/2	22
6 1/2	6	16 3/4	2 3/4	2 1/4	11 1/4	6 3/4	9 1/4	1 3/8	9 1/4	23 3/4
7 to 7 1/2	6	18 1/2	3	2 1/2	12 1/4	7 1/2	10 1/4	1 1/2	10	26 1/4



Section of Clutch

Courtesy Allis-Chalmers Co.

116—CHAIN, LOAD

Weight per Foot, Proof Test and Breaking Weight

Elongation of all sizes, ten per cent. All chain must stand the proof test without deformation. A piece two feet long out of each 200 feet is tested to destruction.

Properties of Chains

Nominal Diameter of Wire. Inches.	Description.	Maximum Length of 100 Links. Inches.	Weight per Foot. Lbs.	Proof Test. Lbs.	Breaking Weight. Lbs.
5/32	Twisted chain..........	103 1/8	0.20		
3/16	" "	96 1/4	0.35		
3/16	Perfection twisted chain	151 1/4	0.27		
1/4	Straight-link chain....	102	0.70	1,600	3,200
5/16	" " "	114 3/4	1.10	2,500	5,000
3/8	" " "	114 3/4	1.60	3,600	7,200
3/8	Crane chain..........	113 5/8	1.60	4,140	8,280
7/16	Straight-link chain....	127 1/2	2.07	4,900	9,800
7/16	Crane chain..........	126 1/4	2.07	5,635	11,270
1/2	Straight-link chain....	153	2.50	6,400	12,800
1/2	Crane chain..........	151 1/2	2.60	7,360	14,720
5/8	Straight-link chain....	178 1/2	4.08	10,000	20,000
5/8	Crane chain..........	176 3/4	4.18	11,500	23,000
3/4	Straight-link chain....	204	5.65	14,400	28,800
3/4	Crane chain	202	5.75	16,560	33,120
7/8	" "	252 1/2	7.70	22,540	45,080
1	" "	277 3/4	9.80	29,440	58,880
1	Straight-link chain....	280 1/2	9.80	25,600	51,200
1 1/8	Crane chain..........	303	12.65	38,260	76,520
1 1/4	" "	353 1/2	15.50	46,000	92,000
1 1/2	" "	416 5/8	22.50	66,240	132,480
1 3/4	" "	479 3/4	30.00	90,160	180,320
2	" "	555 1/2	39.00	117,760	235,520

Experiments have proved that stud chain within the elastic limit will bear from 20 to 25% more load than the open link, but that the alternate strength of the studded link is probably less than that of the open link. The diameter of chain sheaves would be not less than thirty times the diameter of the chain used.

Crystallization

This is a term which has been popularly used as an excuse for breaking of chains, hooks or other metal parts which are used under shocks or repeated stress. This subject has been carefully investigated by the American Society for Testing Materials, with the following result:

It has been shown conclusively that the coarse-grained structure can develop only while the metal is hot and that it cannot be brought about under ordinary service conditions while the metal is cold. In other words, when a broken part which has not been subjected to high temperature in service shows the effect of crystallization, it indicates that the part received improper heat treatment during the process of manufacture or annealing. The coarse-grained structure existed at the time the part was placed in service and was merely revealed by the breakage.

There is no question but that chain and hooks may have coarse internal structure, due to heating in the process of manufacture or annealing. The fine grain can be restored by proper heat treatment, but this requires special heating to the correct temperature and slow and even cooling. This treatment cannot be given satisfactorily in an ordinary shop. If attempted it may result in injury rather than be of value.

GENERAL

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into one cubic foot of steam (approximately).

To reduce United States gallons to cubic feet, divide by 7.5.

To reduce cubic feet to United States gallons, multiply by 7.5.

To find the number of pounds avoirdupois in one cubic foot of any substance, multiply its specific gravity by 62.5.

To find the degree Baumé corresponding to any specific gravity:

$$\frac{140}{\text{sp. gr.}} - 130 = \text{B deg.}$$

To find the specific gravity corresponding to any degree Baumé:

$$\frac{140}{130 + \text{B deg.}} = \text{sp. gr.}$$

Doubling the diameter of a pipe increases its capacity four times.

Double riveting is from 16 to 20 per cent. stronger than single.

A cubic foot of water contains 7½ gallons, or 1,728 cubic inches, and weighs 62½ pounds.

The friction of water in pipes is as the square of the velocity.

The capacity of pipes is as the square of their diameter; thus, doubling the diameter of a pipe increases its capacity four times.

The height of a column of fresh water, equal to a pressure of one pound per square inch, is 2.31 feet. (In usual computation this is taken at two feet, thus allowing for ordinary friction.)

A properly designed boiler, with skillful firing, will evaporate from seven to ten pounds of water per pound first-class coal.

One cubic foot of anthracite coal weighs about 58 pounds, and one cubic foot of bituminous coal from 47 to 50 pounds. A ton loose occupies from 43 to 58 cubic feet.

The average consumption of coal for steam boilers is 12 pounds per hour for each square foot of grate.

Water expands one-ninth of its bulk in freezing.

One horse power is equivalent to raising 33,000 pounds one foot per minute.

One cubic inch of cast iron weighs .26 pounds or about 4 ounces. A cubic foot of cast iron weighs 450 pounds.

Oxalic acid dissolved in soft water, ⅛ ounce to a pint, is one of the best means for cleaning and brightening brass work.

Iron or steel immersed warm in a solution of carbonate of soda (washing soda) for a few minutes, will not rust.

Rust joint (quick setting), sal-ammoniac powdered 1 pound, flour of sulphur 2 pounds, iron borings 80 pounds, mix to a paste with water. (Slow setting), sal-ammoniac 2 pounds, sulphur 1 pound, iron borings 200 pounds. The latter is the best if the joint is not needed at once.

AMERICAN DRESSLER TUNNEL KILNS

1740 East Twelfth Street INCORPORATED **CLEVELAND, OHIO**

PRODUCTS

Tunnel Kilns, Dressler Muffle, Direct Open Fired, and Regenerative Types.

The American Dressler Tunnel Kiln.

SIZE

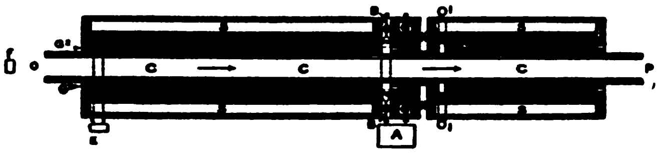
This kiln is constructed in the form of a tunnel. The average lengths required for the Ceramic Industry are as follows:

1. Biscuit Kiln......Average space required, 300 ft. x 24 ft.
2. Glost Kiln........Average space required, 300 ft. x 20 ft.
3. Decorating Kiln ..Average space required, 150 ft. x 20 ft.

The measurements vary according to the output and class of ware.

CONSTRUCTION

The construction is very simple. Cars containing the ware are mechanically propelled by a small electric motor, through the tunnel, which gradually increases in temperature from the mouth of kiln to the hottest point (a little beyond the center). Cars run very smoothly; no danger of ware shaking out of position due to vibration.



FUEL

Producer or natural gas or oil, may be used.

SOURCE OF HEAT

The heat is supplied from two combustion chambers, which run on either side of the car tracks, and extend from the producer almost to the mouth end of the kiln. When the ware has passed the hottest point it enters a cooling zone. The latter has a number of pipes which correspond in position with the combustion chambers in the hot zone, and which run from the tail end of the kiln to flues carrying away the superfluous heat. This surplus heat is drawn from the goods after they have given off all required by the air to burn the gas. The spare heat is considerable and can be used for drying purposes.

UNIFORM TEMPERATURE

The Dressler maintains an absolute uniformity of heat.

EFFECT OF HIGH TEMPERATURES ON BRICK WORK

The repeated heating and cooling of an ordinary kiln has very deleterious effects upon the interior construction, necessitating continuous repairs to bags and flues. Repairs required by the Dressler Kilns are comparatively negligible.

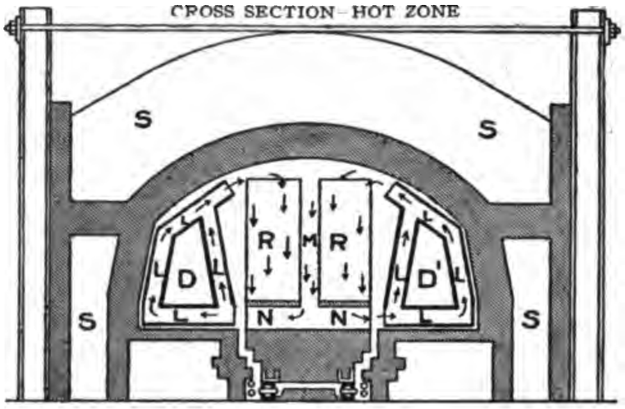
RATE OF TRAVEL—TRUCKS

The usual rate of progression is one truck per hour. Owing to the burning gases being enclosed in chambers, the ware itself does not come in contact with any flame. Consequently, saggers are not required. In fact the Dressler Type is a muffle kiln.

COMPARISON OF OUTPUT BETWEEN OLD KILNS AND THE DRESSLER TYPE

Owing to the scientific methods involved in the construction, the system of firing is quicker than with the old kilns. As regards output, one Dressler Kiln is about equivalent to four 15 foot diameter kilns of the ordinary type.

CROSS SECTION—HOT ZONE



D	Combustion Chambers.	L M N	Air Passages.
R	Ware to be Fired.	S	Insulating Material.

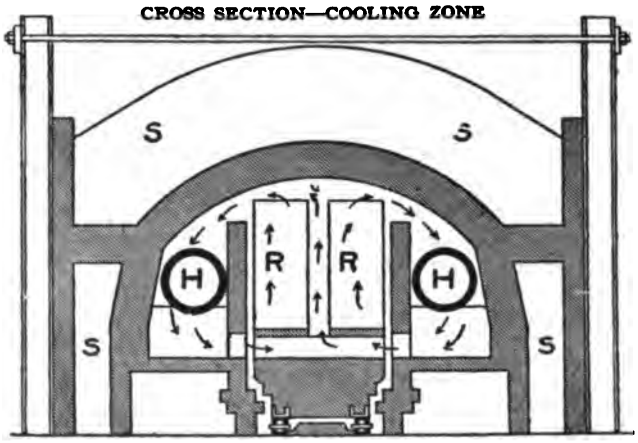
ECONOMIES EFFECTED

The Dressler Tunnel Kiln is so sure of its operation and so simple to work that no skilled labor is necessary.

Saggers being eliminated, a great economy is effected in the labor entailed in handling these, when placing and drawing the ordinary kilns.

The method of placing the ware on the trucks for the Dressler Type is very simple. The trucks have a series of fire clay trays which are set from the shelf surface of the trucks in one or more tiers according to the size and quantity of the articles being fired. By this system you have a minimum of handling which is both beneficial and economical.

CROSS SECTION—COOLING ZONE



The labor entailed in setting and taking the ware off the trucks, as compared with filling and placing in old type kilns, reduces your costs by more than fifty per cent. In fact we estimate that on a twelve kiln plant the kiln setters annually climb up step-ladders at least 230,560 feet, not to mention coming down. Further, a weight considerably more than equivalent to that of the goods fired, is carried in and out of the kiln in the shape of saggers.

THE AMERICAN EQUIPMENT CO.

1619 Conway Building, CHICAGO, ILLINOIS

Manufacturers and Licensors of Patented Labor Saving Machines for Both Stiff Mud and Soft Mud Brick Yards

Including: Hacking Machines, Setting Machines, Machines for Loading Direct from Kiln onto Wagons, Cars or Barges. Complete Mechanical Equipment for Brick Yards.

Minimizing the Labor Problem

The most forceful summing up of the accomplishment of Penfield Systems for the mechanical setting, handling and loading of brick is shown by a comparison of the actual operating figures. A yard with a capacity of two hundred and fifty thousand brick per day now requires about thirty men.

The Loading and Handling of Brick

If marked economy accompany the setting of brick in the kiln by mechanical means, it follows then that it can be loaded and handled more efficiently by such means than is possible by hand. It is for this reason that the loading fork has been designed.

The demand for mechanical loading has been augmented by the employment of the motor truck. The facilities of the truck are only limited by the time required in loading, and this time, when loading is done by hand, is found to be three-quarters of an hour to an hour for a load of three thousand brick. With a loading fork this same amount of brick is loaded into a truck in six minutes! This permits a positive saving of eighty-six per cent. of the time required to load a truck by hand. Therefore, there is a distinct gain of material increase in truck facilities by this saving. This gain is more pronounced in the short and medium length hauls, for it is in these deliveries that the greater amount of time is saved in the loading. Where the loading fork is used, fewer trucks and drivers are required to deliver the same quantity of brick than when hand labor is employed.

Fewer Bats Where Mechanical Loading Is Employed

The result of mechanical loading is not only ease in picking up a load, but also fewer brick broken in loading. There are fewer bats. This means customer satisfaction.

A Superior Product As the Result of Mechanical Setting

In addition to the advantages already enumerated a more uniform burn is assured when kilns are set by machine, due to the elimination of the variations in hand setting. Brick are set by some men more loosely than by others, which causes a lack of uniformity in the burn, resulting in a more variable and inferior product.

With the Penfield System installed, many of the difficulties encountered in the operation of a brick yard are entirely eliminated, and the operating costs are decidedly reduced. These gains are made, and in addition, this system contributes to the production of a superior product; so it is easily discernible why the Penfield System of mechanical setting, handling and loading so strongly recommends itself for installation in every brick yard, if that brick yard is to be a factor in the industry.

THE AMERICAN EQUIPMENT CO.

1619 Conway Building CHICAGO Phone Franklin 1712

American Pulverizer Company

18th and Austin Streets St. Louis, Mo.

PRODUCTS

Crushers and Pulverizers for all refractory materials.

ADAPTABILTY OF OUR STANDARD MACHINES

These machines will crush and pulverize to any desired fineness Shale, Fire Clay, Clay and Shale, Brick Bats, Kaolin, Gypsum, Tile, Crockery, Sewer Pipe, Coal, Grog, etc.

DESCRIPTION

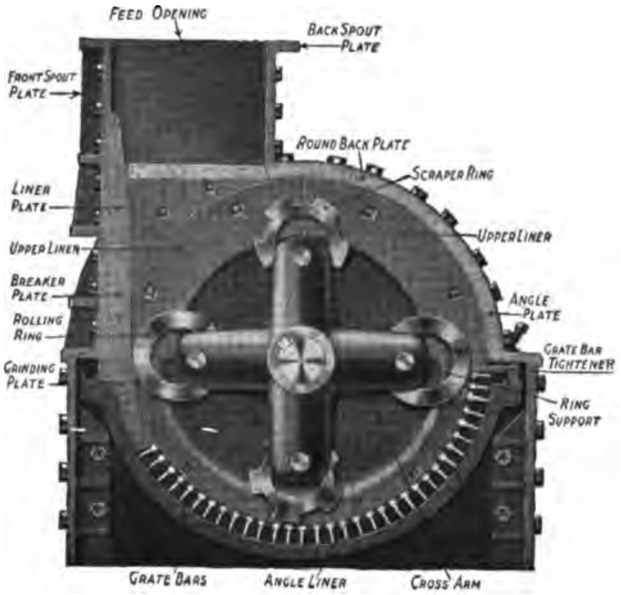
These machines are built on the ring principle. They have a rigid housing, a rotor consisting of main shaft, discs, spider or cross arms, ring shafts, rings, set collars, liners, breaker and grinding plates and grate bars.

The material enters the pulverizer on top, allowing the material to fall direct upon and be struck by the rings while in suspension, thus shattering and distributing the same before reaching the breaker plate, then falling to the concave grinding plate and grate bars for final pulverization. The degree of fineness is regulated by the openings between the grate bars—the capacity is governed likewise.

ADVANTAGES

The advantages of using the American Ring Pulverizer are many. Low speed—only 600 R. P. M. are required to operate these machines effectively. Low power consumption due to the centrifugal force of the Rings. Toggle work adjustments are avoided, because the Ring affords a flexible adjustment within itself. High capacity is obtained. Our No. 48 Machine will ordinarily do the work of two or three Dry Pans.

American Ring Pulverizer Open Equipped with Rolling and Scraper Rings



Cross Section of the Standard American Ring Pulverizer

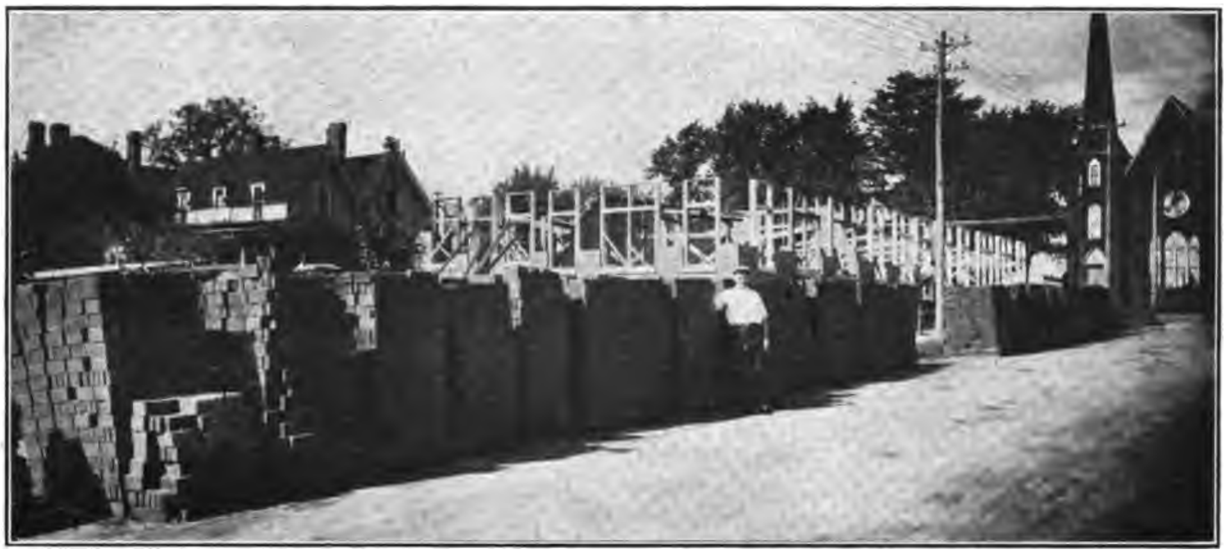
Ease of operation and care, no skilled mechanics are required to replace parts when making repairs. A minimum space is required, because the machines are built low and compact. Foreign material cannot damage the machine. They are reliable and give entire satisfaction to their owners.

ADDITIONAL INFORMATION

Always specify material to be ground and the capacity and fineness required. If possible send us a small sample by mail of the crude material for the mill and the finished product required. We maintain an engineering department which is available for our prospective customers. We guarantee our machines for workmanship and performance. For additional information and catalogues write us.

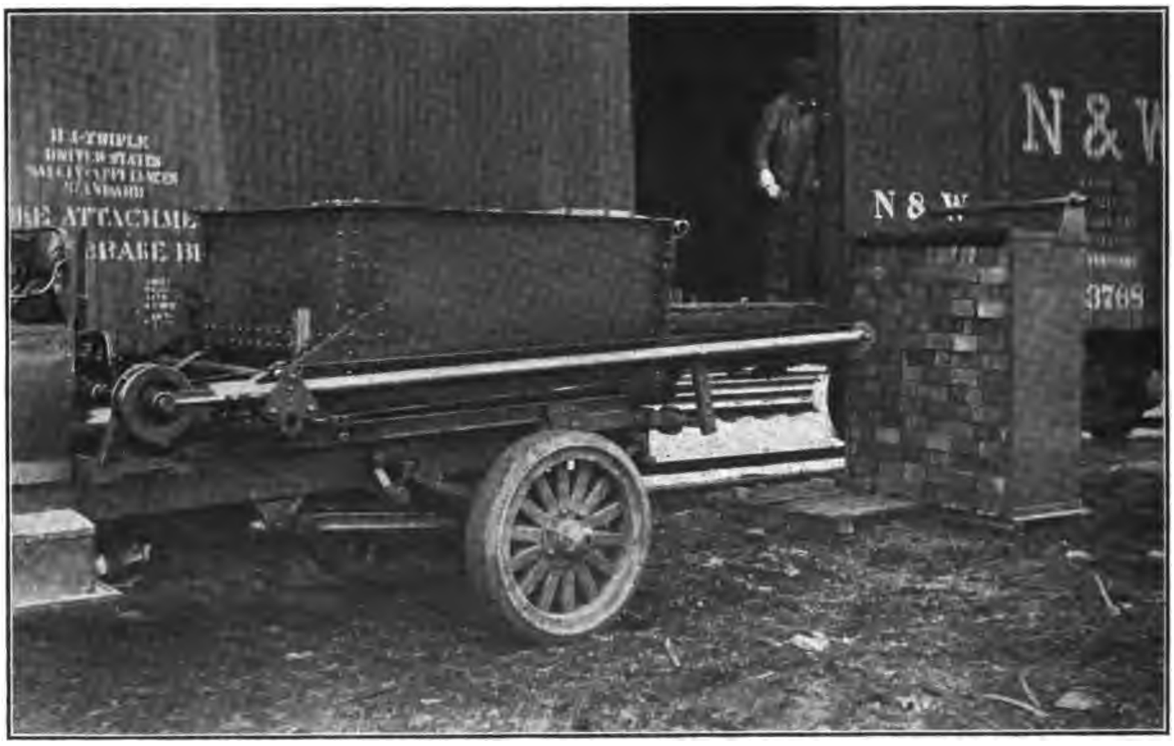
We also refer you to Items Nos. 129, 167 and 502 in the Definition Section

YOU exert every effort to make the best brick possible and at the lowest cost, then why not exert the same judgment concerning deliveries? Wouldn't you like to have your brick delivered like this—



And at the same time—

"With the one truck hauling 1,000 brick each load, we have moved over 30,000 per day, delivering them on an average haul of a mile or more." "It is also instrumental in getting orders as the advantage of having brick delivered in piles with none broken pleases many, and very much so where the job is in a congested street." "Will say that the repairs have only been a few bolts that have been lost, which was due to the carelessness of the driver by not keeping them tightened up; it has proven in every way, perfectly satisfactory to us." "As a time saver, one man and this equipment will get out more brick than two trucks and two men where they have to unload them by hand." "It would not have been possible to have gotten enough mule teams on the yard to have accomplished this delivery."



Showing how body is loaded so that the truck may exchange an empty for a loaded body without loss of time.
Complete information furnished on request. The Fontaine Bodies are made in all sizes handling up to 2,600 brick per load.

American Truck Body Co., Inc. **Martinsville, Va.**

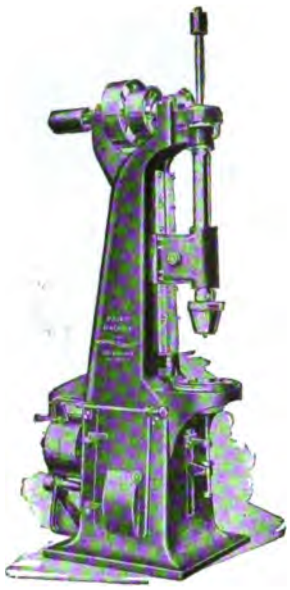
NO. O MACHINE

BAIRD

SEMI-AUTOMATIC

POTTERY MOLDING MACHINES

PATENTED



NO 1 MACHINE

THESE MACHINES MAKE

Flower Pots
Lead Corroding Pots
Graphite Stoppers
Carboy Stoppers
Insulators
Sleeves, Nozzles
Runner Brick
Stoneware Crocks
Milk Pans
Turpentine Cups
Saggers
Plain Pottery

NO. 2 PUG MILL (BESSEMER STEEL BODY)

THE PRINCIPLE IS CORRECT

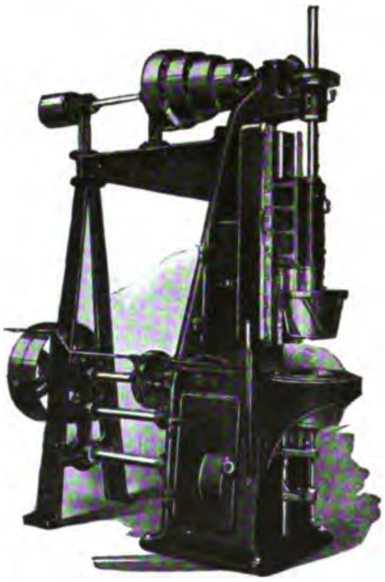
The revolving or spinning motion spreads the clay and distributes it evenly to all parts of the die. This means stronger ware, lower percentage of breakage in handling and burning, quality and uniformity in the finished product.

We guarantee not only to greatly increase production, but to improve the quality and reduce the manufacturing cost of your ware.

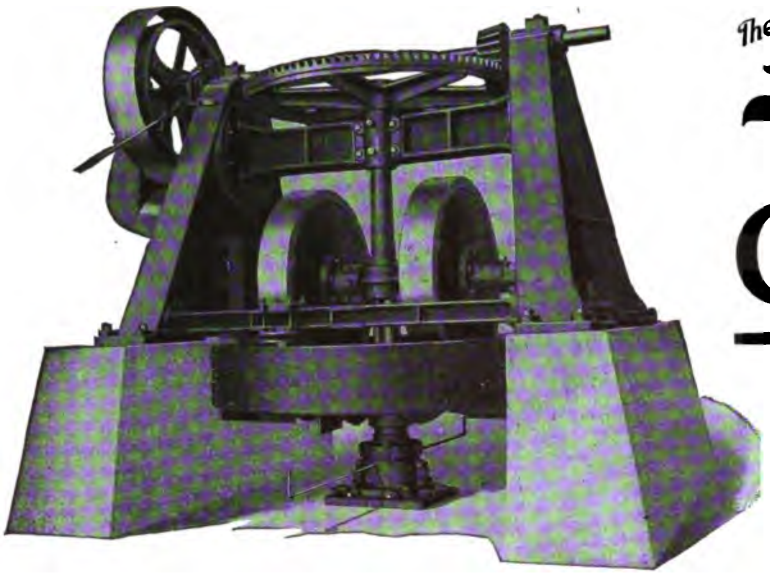
NO. 2 STANDARD MACHINE

Our broad experience in the design and manufacture of machinery of this type enables us to present to the Clay Products Industry the only successful and mechanically correct Pottery Molding Machines in the market. ¶ Recent improvements such as the new type (patented) crank and knockout arrangement and other important features are used on all machines.

Baird
Machine & Mfg. Co.
409-11 Jefferson East
DETROIT, MICH.



NO. 2 HEAVY DUTY MACHINE



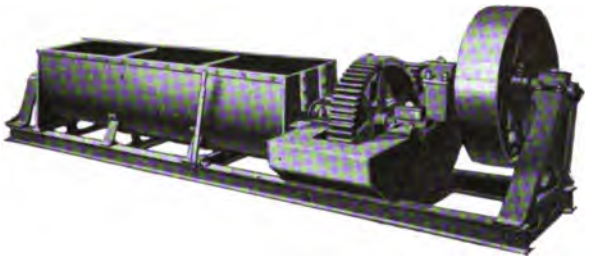
10-foot Bonnot Dry Pan

The Bonnot Company
CANTON, OHIO
"LET US STANDARDIZE YOUR PLANT"

Clayworking

Bonnot Dry Pans

Made with heavy ribbed frames, all joints machined. Equipped with either solid or cored mullers. Sizes up to 10 ft. for dry or wet grinding. A pan that will give long service at low cost for repairs.



Type "G" Pug Mill

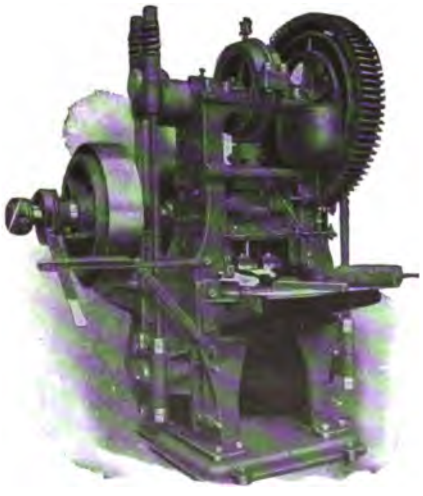
"G" Pug Mill

Double-geared pug mill mounted on 7-in. steel I-beams. Capacity, 5,000 to 7,500 brick per hour.

No. 21 Auger Machine

No. 21 Auger Machine

A recent addition to our line of auger machines, suitable for either brick or hollow ware, with a change of interior parts. With this machine, you can fit your product to the market, at a small expense. Capacity—75 to 125 tons of hollow ware or 40,000 to 50,000 brick per day.



Canton Repress

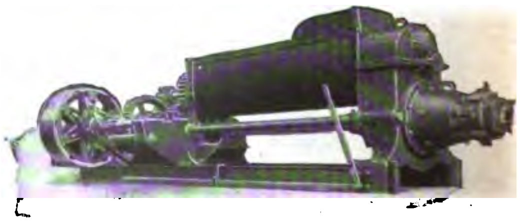
Canton Repress

The smoothest running repress on the market.

No. 14 Combination Machine

Single gear combined machine for 25,000 to 40,000 daily output.

Note—We are in position to make tests of clay for a nominal fee.



No. 14 Combination Machine

The Bonnot Company

CANTON, OHIO

"LET US STANDARDIZE YOUR PLANT"

Machinery

No. 32 Combination Machine

No. 32 Combination Machine

A large machine built for either brick or hollow ware. Weighs 38,000 lbs. Capacity, 200 tons of standard size hollow ware or 100,000 to 150,000 brick per day.

Type "E" 12-foot Pug Mill

Type "E" Pug Mill

Strongly built throughout. Has steel gears. Capacity—10,000 to 15,000 brick per hour. A heavy duty machine.

No. 20 Auger Machine

No. 20 Auger Machine

150 to 200 ton capacity auger machine suitable for either brick or hollow ware. Strongly built and guaranteed to give service.

Clay Feeder

The Bonnot Regulating Clay Feeder is designed to feed ground clay to the pug mill in regular quantities. Made in two sizes.

Rotary Automatic Cutting Table

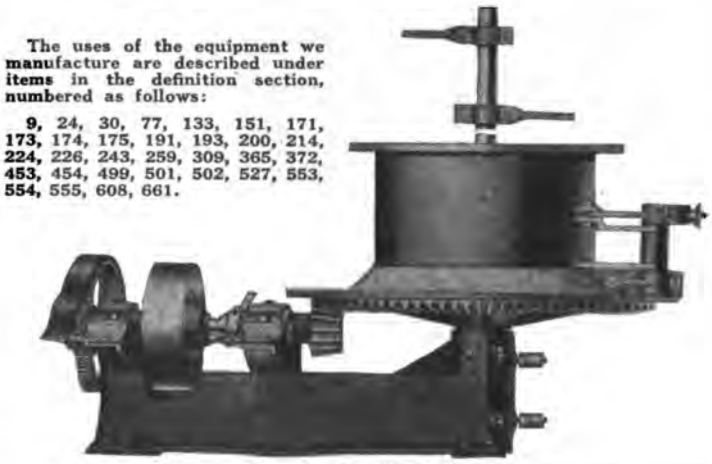
An automatic table that has a capacity of from 3,000 to 10,000 brick per hour.

Note—A complete catalogue showing the entire line of Bonnot Clay Working Machinery will gladly be sent upon request.

The uses of the equipment we manufacture are described under items in the definition section, numbered as follows:

9, 24, 30, 77, 133, 151, 171, **173**, 174, 175, 191, 193, 200, 214, **224**, 226, 243, 259, 309, 365, 372, **453**, 454, 499, 501, 502, 527, 553, **554**, 555, 608, 661.

Rotary Automatic Cutting Table



Regulating Clay Feeder

The Solution To That Burning Question

A

BOOTH RAILROAD TUNNEL KILN

FACTS :: WORTH :: KNOWING

Designed especially for brick yard work.

Built and perfected in a brick yard by a brickmaker of thirty years' experience.

Costs no more to build than down draft kilns of equal capacity.

Adaptable for burning enamels and finer wares.

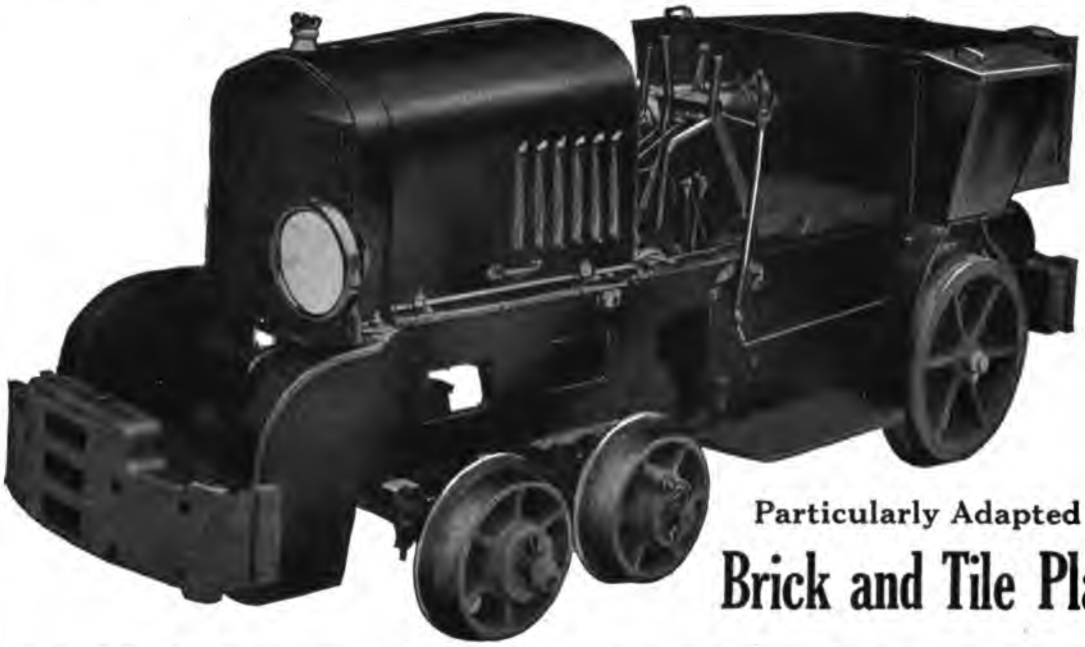
Building brick from pit to job in 3½ days.

Can be seen burning Hudson Shale Building Brick at the plant of The Booth Brick & Lumber Co., New Toronto, Ont., Canada.

THE BOOTH RAILROAD TUNNEL KILN COMPANY

NEW TORONTO, ONTARIO, CANADA

FORD EFFICIENCY APPLIED TO GASOLINE HAULAGE



Particularly Adapted for

Brick and Tile Plants

Suitable for Clay and Coal Mines, Limestone, Sand, Marble and Granite Quarries, Logging and Lumber Operations, Road Construction, or any operation Where a Light Industrial Haulage is desired.

ABSOLUTELY THE MOST EFFICIENT, ECONOMICAL, AND PRACTICAL MOTOR ON THE MARKET TODAY—BAR NONE.

Where loads and grades are not excessive it will do all work of a $5000 machine at a fraction of the cost, with the advantage over other motor of Ford service—Parts obtainable everywhere at a minimum cost.

Will do the work of from two to five horses, handling from two to twenty-five tons per trip according to grade and track conditions, on from four to six gallons of gasoline per day.

HEAVY, ONE PIECE, SOLID CAST IRON UNDERSLUNG FRAME.

Gives ample weight and tractive power to handle all ordinary hauls.

HYATT ROLLER BEARING equipped front pony truck, swiveled, makes sharp curves easy.

POWER, STURDINESS, AND SPEED assured by the Ford Ton Truck Motor, Transmission, and Overhead Worm Drive, supplemented by our Special Auxiliary Reverse Transmission, giving motor the same speeds and pulling power when running either forward or reverse, a low speed up to 4 miles per hour and high speed up to 15 miles, eliminating the necessity of turntables or "Y's".

⅜-in. boiler plate sand and ballast compartments. Sand lever control for either forward or reverse work.

YOU COULD NOT BUY BETTER MATERIALS AND CONSTRUCTION, NO MATTER WHAT PRICE YOU PAID.

Built any gauge from 24 in. to 56 in.

Whatever haulage system you now use, or intend using, get the facts from Brookville first. We can't handle every haul, but where we can, we have no competition.

ASK FOR OUR SPECIAL CIRCULAR

BROOKVILLE TRUCK & TRACTOR COMPANY

BROOKVILLE,
PENNSYLVANIA
U. S. A.

Cut Your Burning Time 1/3 by Equipping Your Kilns with a Brown Pyrometer

The plant shown above saved 1/3 burning time. It is the Glasgow Clay Products Company of Glasgow, Va. Hundreds of other brick plants are making like savings. Are you?

These savings in burning time are made because the Burners know the temperature of every kiln for every minute of the burn.

On the one instrument shown above—the Brown High Resistance Indicating Pyrometer—the temperatures of any number of kilns can be seen at a glance simply by the turning of the knob.

At the same time in the Superintendent's office, a Brown Duplex Recorder similar to the one seen at the right is mechanically making a temperature record for every minute of the day and night. Side by side, two records are made on one chart. This chart, with its carbon roll, which makes the record, will last approximately for two months without renewal. The only attention necessary is the winding of the clock once a week from the outside of the case.

Above the Duplex is the Brown Plug Switch. Every kiln is wired to a hole in this box, and by inserting a plug, the kiln is attached to the Recorder. In this manner, only the kilns actually burning are attached, and only a minimum number of Recorders are required.

Tell us the number of your kilns, kind of product, and approximate output, and our Pyrometer Engineers will outline the proper Pyrometer equipment for your plant—there is no obligation.

Address: The Brown Instrument Company, Philadelphia, or District Offices at New York, Pittsburgh, Chicago, Detroit, St. Louis, Denver, San Francisco, Los Angeles, Montreal.

The New Brown Recording Thermometer For Use in Dryers and Power Plants

Keep a record of the temperature of your Dryers. Don't let this end of your plant hold up production. A Brown Recording Thermometer is especially adaptable for use in Dryers. Every instrument has moisture-proof case as standard equipment, and is supplied at no extra charge.

This Thermometer incorporates all the latest improvements of other Thermometers, and many exclusive Brown patented features.

You will also find a type of this new Brown Recording Thermometer especially fitted for your power plant needs.

Write today for Catalog No. 62

BUILDING SUPPLY NEWS

407 So. Dearborn Street, Chicago, U. S. A.

Members of the Associated Business Papers and Audit Bureau of Circulations

A $3,000,000,000 Sales Field Now Open for Your Clay Products

The most accurate and complete figures possible, compiled by the Architectural Forum thru the co-operation of the leading architects of America, show that the total amount of building construction contracted for and expected during 1922 will run close to $5,000,000,000.

At a very conservative estimate the retail building supply and lumber dealers thruout the country now sell at least 75 per cent. of all materials used in construction.

Building Supply News covers this retail field for you. It is pushing all the time the expansion of the clay products business thru the retail dealer, as a vital and increasing part of the every-day sales of the average progressive retail yard.

It is teaching hundreds of dealers how to sell clay products more effectively and it is teaching them more about building tile, common brick, face brick, fire brick, drain tile and sewer pipe with every successive issue.

It offers you new business, new prospects and permanent and dependable sales representatives in every town and city in the country.

It is the leader and the foremost advocate in the construction industry of 100 per cent. Sales and Service Co-operation between the manufacturer and the retailer. It has the unqualified confidence of the retail building supply man. **Its record of 87 per cent. renewals of regular subscribers proves its value as an advertising medium.**

Why It Covers the Field

Here are a few reasons that make it the most progressive trade paper thruout the retail field:

It publishes regularly 5,000 Retail Prices Current upon 75 different items, including all clay products, from 80 cities thruout the United States and Canada.

It maintains for its dealer readers, **as a service of its editorial department,** an **accurate and inclusive Directory and Buyer's Guide of Manufacturers, Producers and Wholesalers** of construction materials, including every clay product handled by the retail dealer.

Its Super Service Department carries in every issue the latest sales methods and the most successful suggestions for merchandising clay products and other materials.

It is the only publication endorsed by the National Builders' Supply Association and by practically every other organization of retail building supply dealers thruout the country, including New England Builders' Supply Assocation, the Michigan Builders' Supply Association, the Iowa Builders' Supply Association, the Indiana Builders' Supply Association, the Ohio Builders' Supply Association, the New York State Builders' Supply Association, the Mason Material Dealers' Association of New Jersey, the Building Material Dealers' Association of Eastern Pennsylvania, the West Virginia Lumber & Builders' Supply Association, and by many local bodies.

It is the author of the Only Uniform Cost Accounting System for the Retail Building Supply Dealer ever produced, which is being rapidly installed thruout the country, and it is constantly advocating and championing every means and method whereby efficiency, initiative and greater sales results can be achieved by the retail dealer—the manufacturer's logical representative wherever he is doing business on the progressive basis.

Building Supply News has a **Special Service Department for the Manufacturers,** which is always at the disposal of the advertiser and which is every day helping to boost the profits of the producer who desires to take advantage of this opportunity to reach this $3,000,000,000 sales field.

The Dealers' Own Paper
BUILDING SUPPLY NEWS
IMPORTANT!
don't fail to read what the trade have to say in this issue about Complete in a Sack—

D-72

All details of its constituency and field from the point of view of the advertiser are open to all. It is well worth your while to be represented in its pages in every one of its twenty-six issues each year. For further particulars write Building Supply News, 407 S. Dearborn St., Chicago, U. S. A.

W. E. CALDWELL CO., INC.

MANUFACTURERS OF

TANKS and TANK TOWERS

2510 Brook Street LOUISVILLE, KY.

THE TANK WITH A REPUTATION
Caldwell
TANKS AND TOWERS
TRADE-MARK

Products.

Wood, Steel and Galvanized Iron Tanks; Tank Foundations; Tubular, Angle or Channel Column and Wood Towers; Friction Clutches and Pulleys.

Also manufacturers of Steel Stacks, Standpipes, Tank Agitators; Water Supply Systems; Gearing and General Power Transmission Machinery.

Industrial Tanks.

Tanks for industrial and special purposes, in wood or steel—round, rectangular, elliptical, or any shape.

Wood — This company specializes in cypress, as it is the best wood for tanks for most purposes. It has great durability, minimum shrinking and swelling and does not give taste or color to drinking water.

WOOD TANKS

Fir, yellow pine, white pine, white cedar and poplar are also used.

Specifications — Lumber is thoroughly dried, without loose or unsound knots, splits, shake, peck or wormholes or other defects. All heart on inside, sound sap on outside only, not to exceed one-half the thickness.

Thickness: 2 in. for 10,000 gals. and smaller; 2½ in. up to 20,000 gals.; 3 in. for larger sizes. Finished thicknesses are 1¾, 2¼ and 2¾ in., respectively.

Standard Inside Diameter: Every 6 in. from 3 ft. to 9 ft., every foot to 16 ft., and every 2 ft. above 16 ft.

Standard Inside Depth: 1 ft. 5 in.; 2 ft.; 2 ft. 5 in.; 3 ft.; 3 ft. 5 in.; 4 ft.; 4 ft. 5 in.; 5 ft.; 5 ft. 5 in.; 6 ft.; 6 ft. 5 in.; 7 ft. 5 in.; 9 ft. 5 in.; 11 ft. 5 in.; 13 ft. 5 in.; 15 ft. 4 in.; 17 ft. 4 in.; 19 ft. 4 in.; 21 ft. 4 in.; 23 ft. 4 in.

Workmanship: Staves dressed both sides. Edges machine jointed to proper bevel. Bottom dressed on top side only. Machine jointed straight and square and well doweled.

Hoops: Round hoops of wrought iron (not steel) with malleable iron draw lugs; sizes and spacing to give a safety factor of 4 to 1.

DIMENSIONS AND CAPACITIES OF STANDARD TOWER TANKS

Class Towers*	Capacity, gals.	Standard Wood Tanks				Standard Steel or Galvanized Tanks			
		Diameter ft.	in.	Depth ft.	in.	Diameter ft.	in.	Depth ft.	in.
O tubular	1,000	6	6	4	5	6	0	5	0
or C. C. angle	1,500	6	6	6	5	6	6	6	6
A tubular	2,800	8	0	7	5				
or FF angle	3,000	8	0	8	5	8	0	8	0
B tubular	5,000	10	0	9	5				
or HH angle	6,000	10	0	11	5	10	0	10	0
C tubular	10,000	12	6	11	5	12	0	12	0
or JJ angle	12,000	12	6	13	5				
D tubular	15,000	14	0	13	5	14	0	14	0
or KK angle or LD latticed	17,000	14	0	15	5				
E tubular	20,000	16	0	13	5	16	0	14	0
or LL angle or LD latticed	22,000	16	0	15	5				
ES tubular or LES latticed	25,000	16	0	17	4	16	0	18	0
F tubular	30,000	18	0	15	4	18	0	18	0
or LF latticed	33,000	18	0	17	4				
FS tubular or LFS latticed	35,000	18	0	19	4	18	0	20	0
G tubular	36,000	19	6	17	4				
or LG latticed	40,000	19	6	19	4	20	0	18	0
LH latticed	50,000	22	0	17	4	22	0	18	0
	55,000	22	0	19	4	22	0	20	0

*Hemispherical bottom steel tanks and towers are regularly made in capacities from 10,000 gals. up. Any of the above towers can be made to suit special conditions.

Steel—Thin galvanized tanks are recommended only in small sizes and for intermittent or temporary use.

Heavy steel tanks made in any shape or size.

Specifications—The standard diameters and depths are in even feet. The standard thicknesses are ⅛ in. up to and including 10 ft.; $\frac{3}{16}$ in. up to 16 ft.; ¼ in up to 24 ft., and $\frac{5}{16}$ in. above 24 ft.

These can be furnished set up, in the smaller sizes, or knocked down, all punched, fitted and bent to shape with the necessary rivets.

Tank Foundations.

Plans for foundations on the ground will be furnished. Designs of, and prices on, foundations for special conditions will be submitted on receipt of a sketch with full dimensions.

Tank Towers.

Tubular Column — Classes O to G built with tubular steel columns and struts, in heights of 15 ft. and every 12-ft. interval above to 100 ft.

30,000 GAL. CYPRESS TANK ON 51 FOOT TUBULAR TOWER

Angle Column — Classes CC to LL built with steel angles for columns and struts, in heights of 12 ft. and every 10-ft. interval above to 102 ft.

Latticed Column — Classes LD to LH built with latticed steel channel columns and struts (bridge construction), in heights of 20 ft. and every 5 ft. above to any height.

Note: Above types of towers are for flat bottom tanks (see table) and are furnished with either a steel or wood foundation for the tank at the top.

Hemispherical All-steel Tanks and Towers—Made with latticed columns and struts in all capacities and heights.

Caldwell Friction Clutch.

The basic principle of this clutch is identical with that of the standard automobile service brake; a flexible band lined with Rabestos and tightened with a single lever. There are only eleven parts. One screw adjusts it, shortening or lengthening the band which gives equal pressure everywhere around the friction ring.

CALDWELL FRICTION CLUTCH PULLEY

The Canton Grate Company

1709 Dillon Place - CANTON, OHIO

PRODUCTS

Rocking and dumping grates for boilers and kilns.

CANTON KILN GRATES

Canton Kiln Grates of the rocking and dumping type are designed to meet the special requirements of the kilns for burning fire brick, red brick, paving brick, sewer pipe, drain tile, pottery, etc., any place where high temperatures are required and where heat regulation is an important matter in getting the most uniform results.

Nearly six years of continuous service with Canton Kiln Grates have demonstrated the following:

A saving of from 25 to 40 per cent in fuel.

A wonderful saving in the cost of brick work in the fire box.

Reduction in labor of firing and cleaning.

Heat to which firemen are usually subjected, eliminated; therefore, attracting a better grade of workmen.

Absolute control of oxidation, reduction and heat flow.

The burning of cheap coal, reducing fuel bill and rendering the plant independent of coal seizure by carriers in times of trouble.

Stability; a record of over five years in burning high grade fire brick, without replacing a single grate bar.

Canton Grates are made to suit any size fire pocket.

Write us for prices and our new catalog. You will be surprised with the low cost and small expense for installation.

CANTON BOILER GRATES

Canton Boiler Grates are made from select brands of pig iron which have been found to give the greatest strength and to resist heat. Their construction is such that they will not warp, as the bars are double braced. The rocking grate eliminates necessity of opening the fire doors to slice the fire and to rake down the ashes, which operation results in the admission of large quantities of cold air that not only chills the boiler and furnace, retarding combustion and lowering economy, but is very destructive to the furnace lining, causing the fire brick to chip off freely.

ADVANTAGES

Saving of fuel. Canton Grates mean clean fires and the admittance of proper amount of air for complete combustion.

Saves labor. With the Canton Grate you have a smaller amount of coal to handle, and no ash and clinker to pull out through the fire doors. In many cases the time required in keeping a clean fire has been reduced to less than one-quarter of that required with common grates. These grates are usually cleaned up once in twenty-four hours.

Increased boiler capacity. Canton Grates mean a twenty per cent increased boiler capacity for regular service, and with no additional strain on your boiler, as the uniform temperature of the fire can be maintained.

It is such advantages that are causing modern plants to rapidly install Canton Grates instead of common grate bars.

SIL-O-CEL

PREVENTS HEAT PENETRATION

TRADE MARK REGISTERED U.S. PATENT OFFICE

Kiln Insulation

Saved 1350° Heat Loss

Clay men recognize that a large percentage of the heat generated in uninsulated kilns passes through the walls and crowns and is lost for productive work.

At the plant of the Bradford Brick and Tile Company, Bradford, Pa., Sil-O-Cel Insulation prevented a heat waste of 1350 degrees on their Diessler Tunnel Kilns. A recent letter states in part:

> "We used about half of a car of your Sil-O-Cel Powder on the Diessler Kiln which we constructed during the first half of the present year. It is 342 ft. long and is insulated on the top with 9 in. to 10 in. of the powder and on the side with 3 in. to 9 in. of the same.
>
> "In the hottest part of the kiln the temperature inside the crown is 1950 degrees, and the temperature on the outside of the 12-in. covering of Sil-O-Cel is practically room temperature. A person can hold his hand comfortably on the outside of this powder. The outside of the arch of the crown, which is built of 9-in. fire brick covered with 2-2½-in. layer of fire brick laid flat, is red hot and will set fire to a stick inserted through the coating of Sil-O-Cel Powder."

Placed on the walls and crown of all types of kilns, Sil-O-Cel Insulation checks the flow of escaping heat and effects a considerable saving in fuel. By maintaining a uniform temperature, more perfect ware is secured. Outer brick work is protected from temperature strains, and the life of the kiln is increased.

The high melting point of Sil-O-Cel Insulation, low heat conductivity and ample mechanical strength make it the ideal insulation for your kilns. An engineering department is maintained for the purpose of providing specifications, blueprints and detailed information. Address nearest office for bulletin and samples.

The use of the materials we produce are described under items numbered 60, 71, 108, 109, 110, 259, 265, 288, 332, 353, 354, 371, 392, 463.

---whether you are repairing, rebuilding or constructing kilns of any type, insulation is an investment, not an expense.

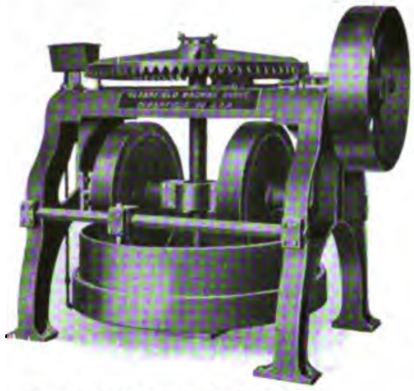
CELITE PRODUCTS COMPANY

NEW YORK-11 BROADWAY DETROIT-BOOK BUILDING DENVER-SYMES BUILDING
PHILADELPHIA-LIBERTY BLDG CHICAGO-MONADNOCK BLDG LOS ANGELES-VAN NUYS BLDG
CLEVELAND-GUARDIAN BLDG ST. LOUIS-RAILWAY EXCHANGE BLDG SAN FRANCISCO-MONADNOCK BLDG
NEW ORLEANS-WHITNEY CENTRAL BANK BUILDING

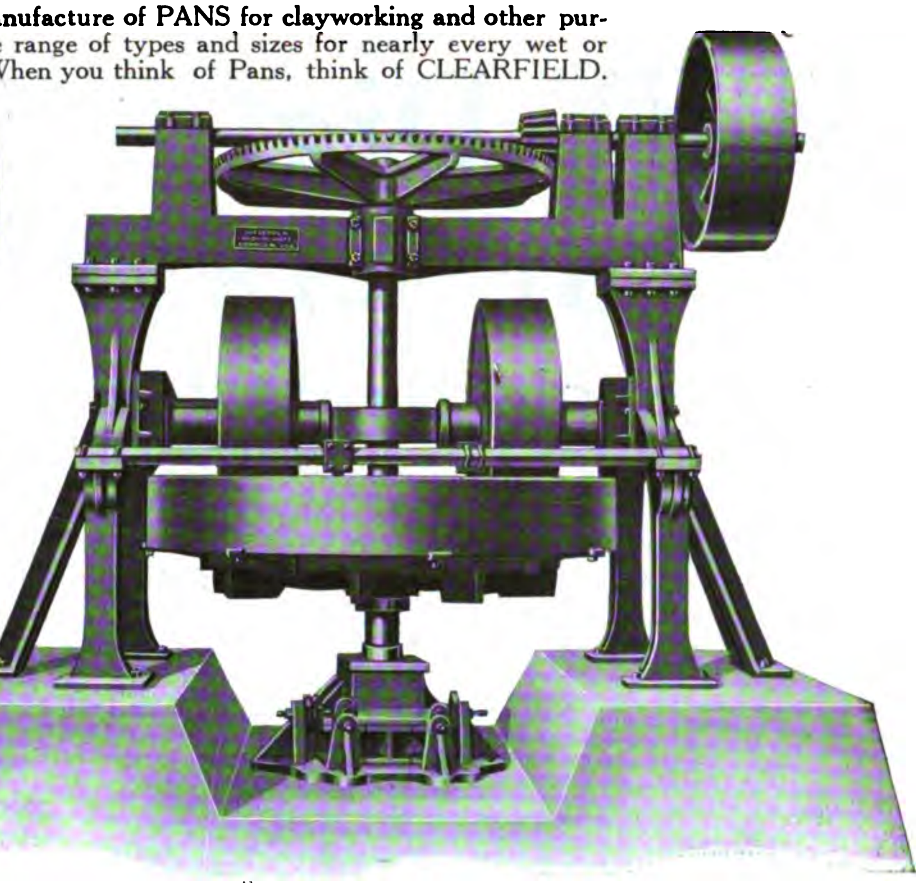
CLEARFIELD MACHINE SHOPS

CLEARFIELD, PA.

Specialists for fifty years in the manufacture of PANS for clayworking and other purposes. Our line covers a complete range of types and sizes for nearly every wet or dry grinding or mixing purpose. When you think of Pans, think of CLEARFIELD.



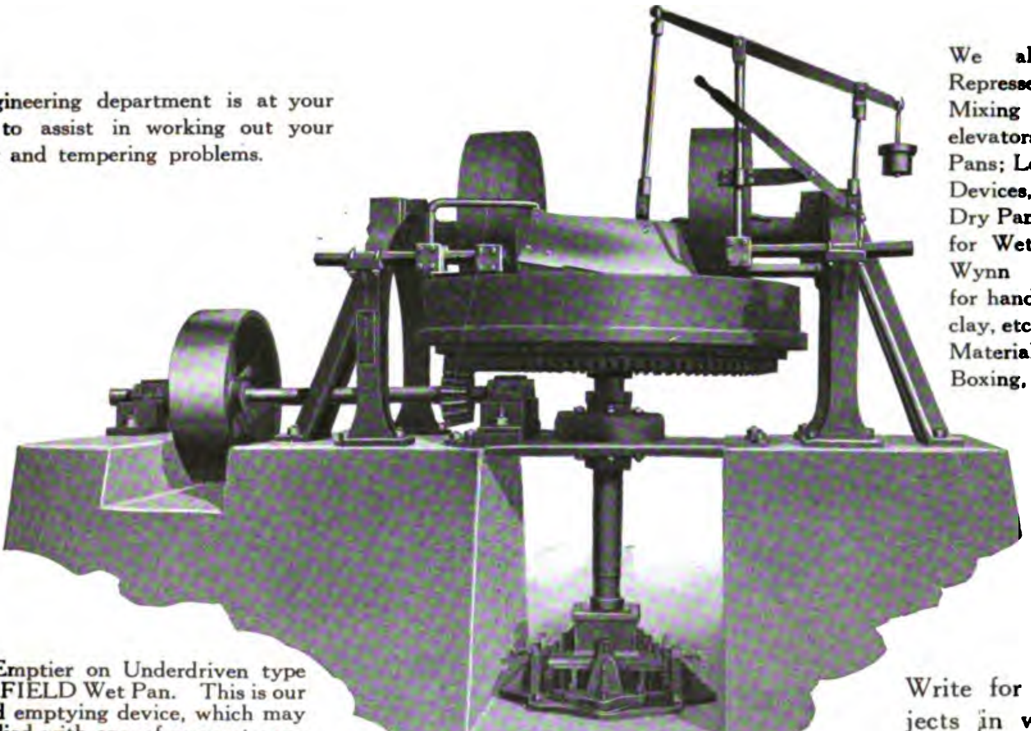
Five-foot Wet or Dry Pan, the smallest, but by no means the least efficient pan in the CLEARFIELD line.



Type of eight and one-half, nine and ten foot Dry Pans. We build grinding pans up to 75,000 pounds—the strongest, heaviest and highest capacity pans in the world.

Our engineering department is at your service to assist in working out your grinding and tempering problems.

We **also make: Hand Represses for fire brick; Lime** Mixing **Tubs for silica brick;** elevators **and screens for Dry** Pans; **Loading and Measuring** Devices, **for charging Wet and** Dry **Pans; Unloading Devices,** for **Wet Pans, including the** Wynn **Emptier; Conveyors,** for **handling raw clay, ground** clay, **etc.; Heavy Transmission** Materials, **Pulleys, Clutches,** Boxing, **etc.**



Wynn Emptier on Underdriven type CLEARFIELD Wet Pan. This is our patented emptying device, which may be supplied with any of our wet pans of either overhead or underdriven style. **We also have attachments for fitting it to most other makes of pans.**

Write for **Bulletins on subjects in which you are interested.**

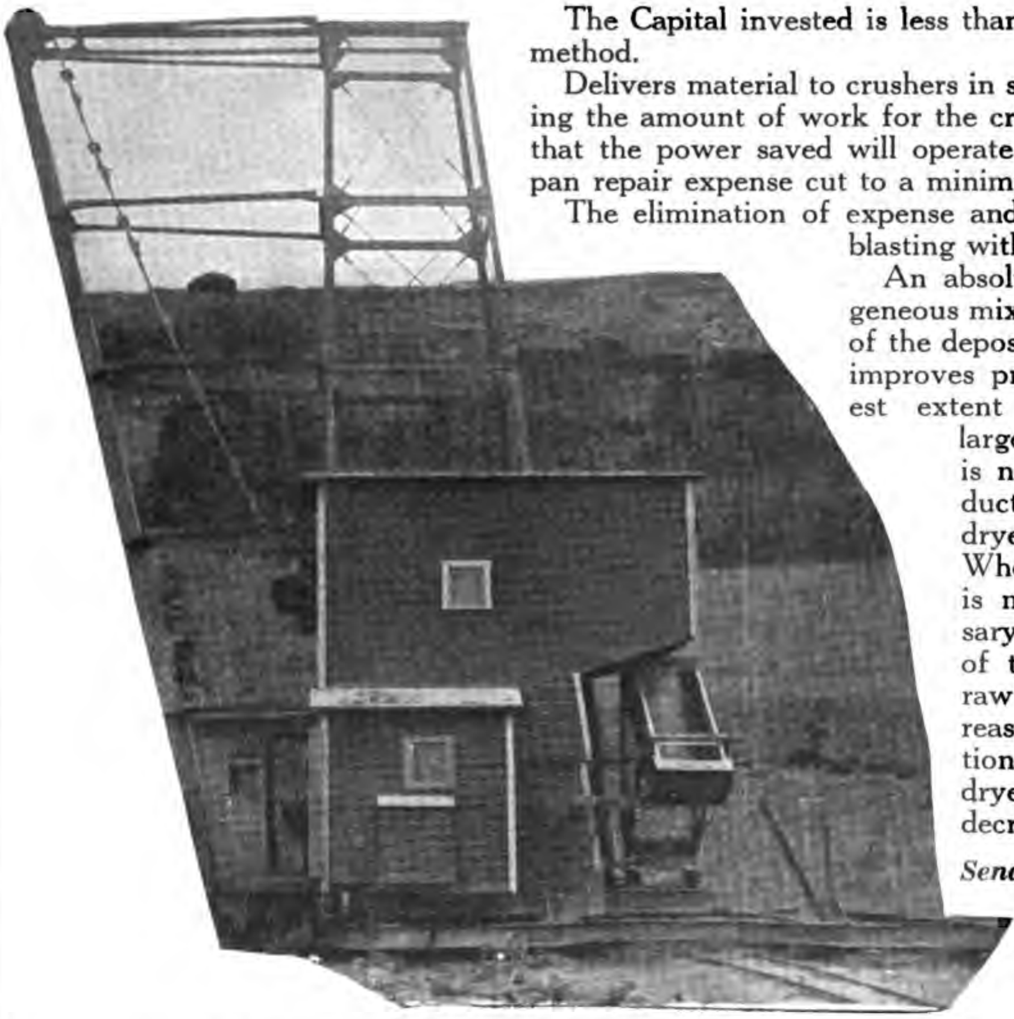
OUR NAME IS YOUR GUARANTEE OF QUALITY

EAC

Will Dig, Mix, Load, or Clay With the

The Eagle Shale Planer

Mixture---Economy---Output



The Capital invested is less than any other machine method.

Delivers material to crushers in small particles reducing the amount of work for the crushers to the extent that the power saved will operate the Planer and the pan repair expense cut to a minimum.

The elimination of expense and danger incident to blasting with explosives.

An absolute, uniform homogeneous mixture of all the strata of the deposit is obtained. This improves product to the greatest extent and eliminates a large amount of care that is necessary in the production room, in the dryer and in the kilns. When proper regulation is made, it is unnecessary to change, because of the uniform run of raw material. For this reason, machine production is increased, and dryer and kiln losses decreased.

Send for Bulletin SP-1

It Will Pay You

We shall be glad to refer you
one of our engineers

The
EAGLE SHALE
PLANER

EAGLE I
DES MOINES,

LES

and Prepare Your Shale Utmost Efficiency

The Eagle Dry Pan

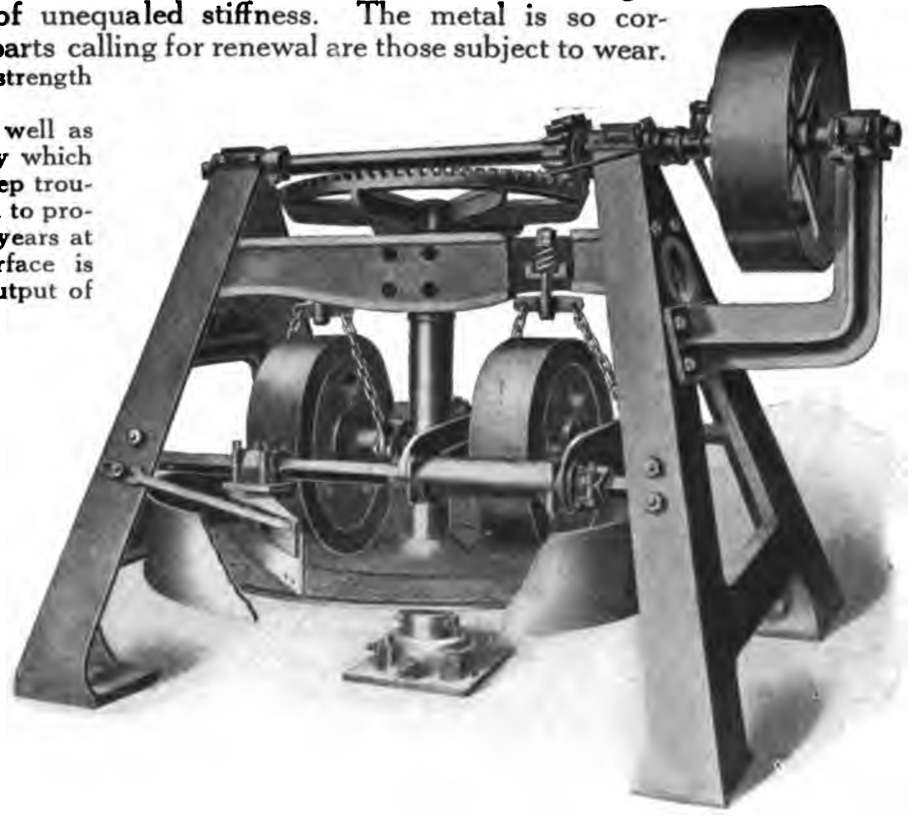
Superiority---Service---Capacity

Mullers suspended and independent, the feature that has put the Eagle in a class by itself, free movement independently, no uneven wear on tires, spring cushioned chain hangers absorb shock and jar incident to grinding. No bushings to wear out and the tires easily and cheaply replaced.

A massive frame with a correct distribution of the metal with the heavy truss and the 3½ inch square steel shafts which support the heavy hinged yokes produce a housing of unequaled stiffness. The metal is so correctly distributed the only parts calling for renewal are those subject to wear. A glance at the cut shows the strength —the picture speaks for itself.

Designed for production as well as service, it has an easy capacity which insures long life with little upkeep troubles. No effort has been spared to produce a pan that will grind for years at low cost. Our screening surface is large, insuring the maximum output of ground material. Repeat orders always carry with them the high testimonial of complete satisfaction; question the user of an Eagle.

This pan is a result of over 30 years' experience in building them and the proof of their merit is their use in nearly every state in the Union and Canada.



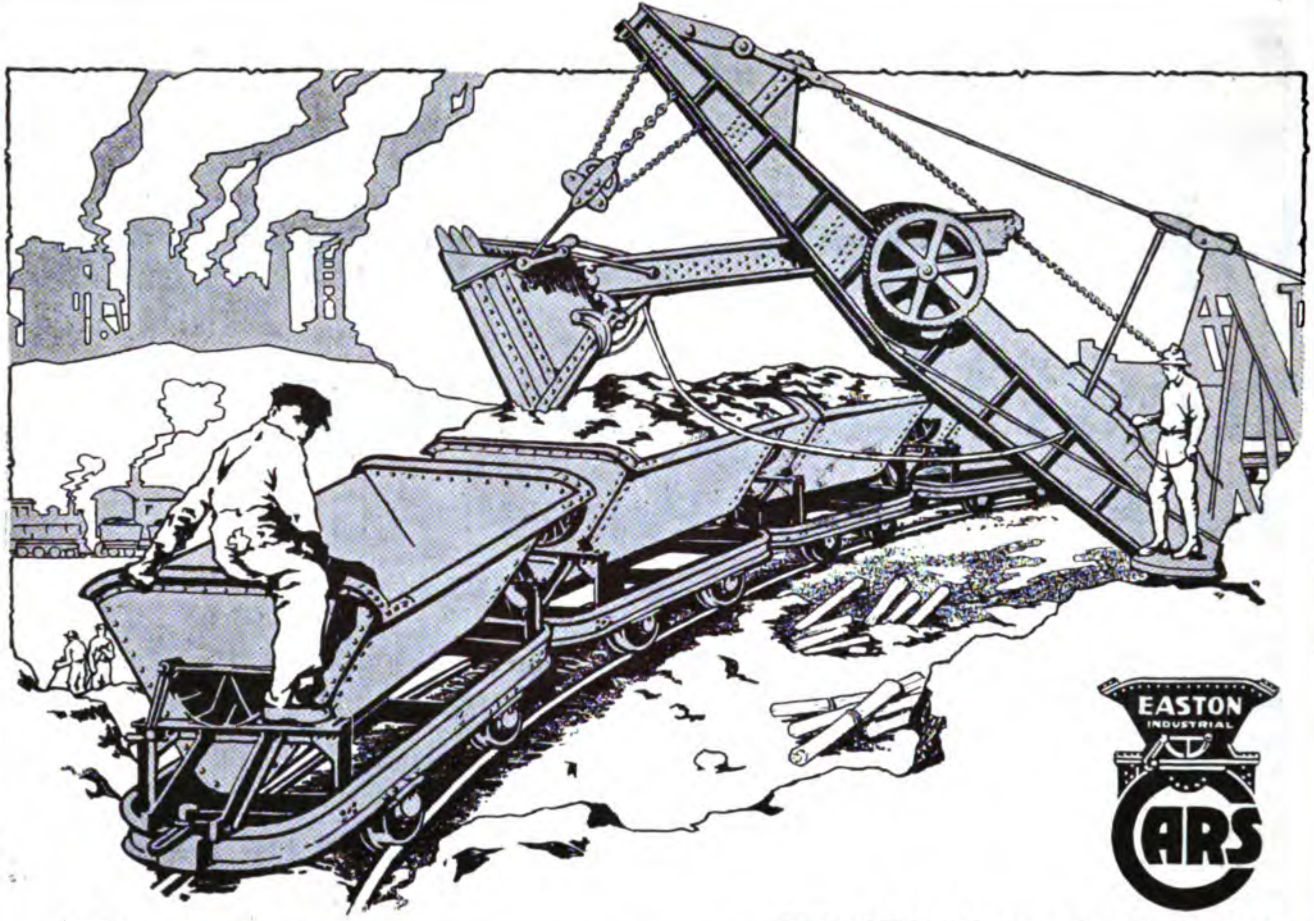
Send for Bulletin DP-1

vestigate Now!

of the users of EAGLES or
over your conditions

ON WORKS
IOWA

The
EAGLE DRY PAN



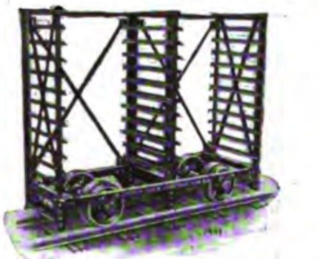


Fig. 1485
Dryer and Kiln Cars of all kinds

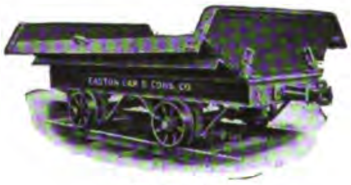


Fig. 107
Clay Handling Cars of every type, gauge and capacity.

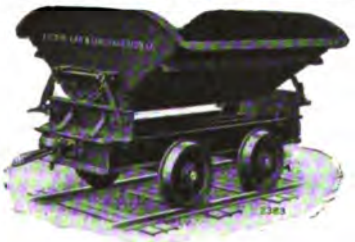


Fig. 2383
Rocker Dump Cars of any type, for any track gauge, of any capacity, for any type of haulage; for stripping, coal and clay handling.

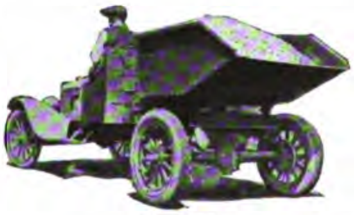


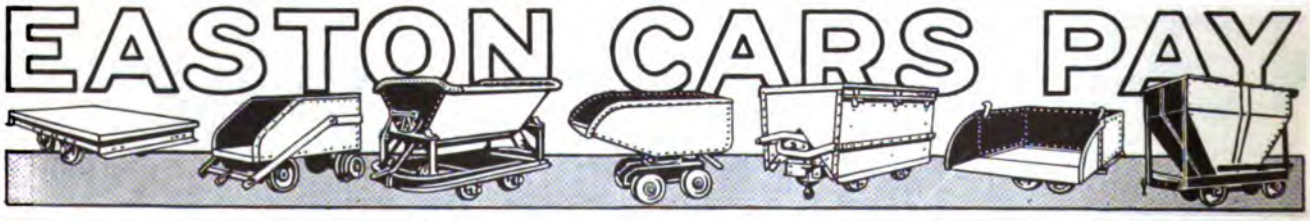
Fig. 111
Auto Truck Bodies, self-dumping, all-steel, for all makes of truck; for handling refuse, wood, coal, clay, brick, etc. Low in price, quickly attachable and detachable.

EASTON Cars and complete narrow-gauge railway equipment are available for every requirement in the Ceramic Industry—clay, shale, and coal-handling cars; dryer and kiln cars; rails and accessories, switches, frogs, turntables, etc.

Standard cars can be furnished from stock and special cars can be constructed either from user's or builder's designs.

This Company, with over 30 years' experience in building cars and narrow-gauge railway equipment for all industrial purposes, is especially equipped to serve the Ceramic Industry. Its intimate knowledge of operating conditions and requirements, and its many years of study of car types and equipments, enable it to furnish *cars and equipment that will pay*.

EASTON CAR & CONSTRUCTION COMPANY
200 Fulton Street New York, N.Y.
Boston Chicago Detroit
Philadelphia Pittsburgh



ENGELHARD PYROMETERS

Engelhard Pyrometers have been standard equipment in ceramic plants in the United States for many years. The outstanding features of their work have been their long accurate service and the records they have made for low maintenance cost.

There is no mystery involved in making accurate pyrometers that will work with low maintenance cost. It is simply a question of adapting each part of the equipment to the work it is called upon to perform. The principal sources of maintenance expense are:

1st. Poor thermo-element wires.
2nd. Inadequate protection.
3rd. Friction in the instruments.

Our Le Chatelier Platinum thermo-elements are made of chemically pure metals and are are ones which, under the name "American," have shown up so well in the recent life tests conducted by the Bureau of Standards. We also supply all of the ordinary base metal elements and the base metal known as Unicurve which has the same calibration characteristics as our Le Chatelier platinum couples.

We have developed Impervite porcelain protecting tubes which are absolutely gas tight and prevent contamination of both rare and base metal couples, and so enable them to maintain their calibration.

All of our instruments have double suspended moving systems which are frictionless and very strong. In addition to this our recording instruments are the simplest and have the fewest moving parts of any on the market. There is practically nothing in them that can get out of order.

We find that the most satisfactory pyrometer performance comes as a result of careful study of the conditions existing in the plants where the pyrometers are to be installed. We much prefer to quote after obtaining a complete description of the kiln equipment in your plant as this enables us to recommend equipment which will give you the best service. Please be as specific as possible when writing us and remember that many ceramic plants have found by experience that

Engelhard Pyrometers Are Good Pyrometers To Standardize On

Catalogue Z-2 on Request

CHARLES ENGELHARD, Inc.

30 CHURCH STREET :-: NEW YORK CITY

E. M. FREESE

Manufacturers

Brick, Tile and Fire

GALION,

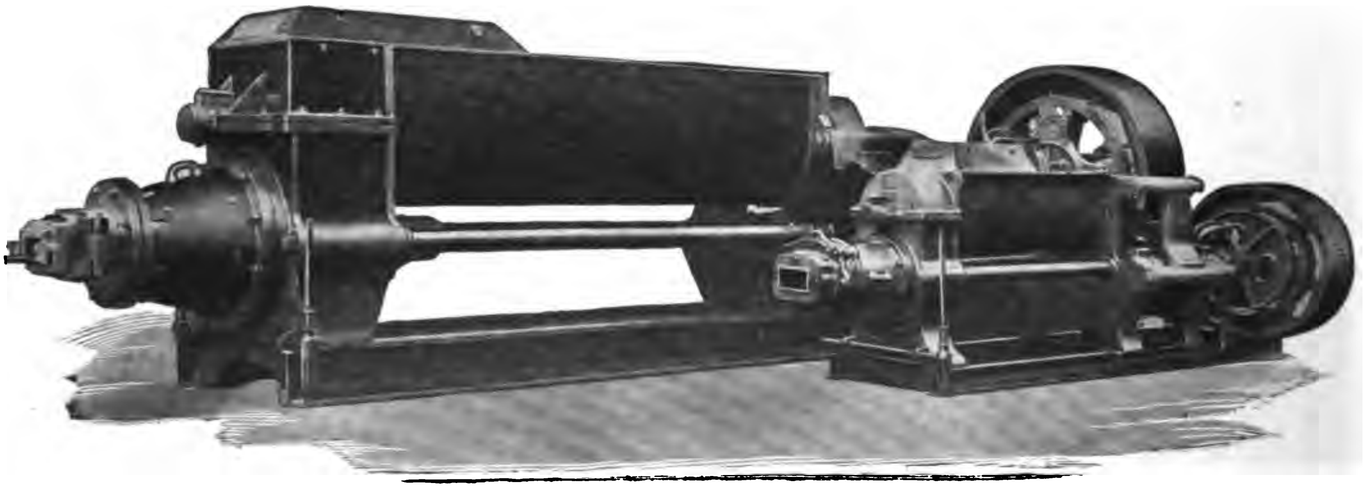
Union Hollow-ware Machine

The Union Hollow-ware Machine has a positive forced feed into the auger, of special importance in the manufacture of hollow-ware. Used by a large percentage of hollow-ware manufacturers of this country. Built in 8 types and sizes. For capacities up to 25-tons per hour.

Automatic Disc Feeder

The Automatic Disc Feeder. Built in 3 designs, belt or chain drive. We furnish automatic feeders for feeding wet or dry surface clay, pulverized material, crushed shale and fire clay, or material in its raw form.

Freese Union Brick Machine. Built in 11 patterns and sizes with capacities of from 1,000 to 15,000 brick per hour. Pug Mill and Auger Machine in one construction. Economical to install and operate, eliminating one set of gears, one driving belt and pulley, and the structural work necessary to support an independent pug mill. Allows storage bin above machine without excessive building height.



Freese Union Brick Machines

WE FURNISH ALL ITEMS NECESSARY TO THE COMPLETE EQUIPMENT

AND COMPANY

of

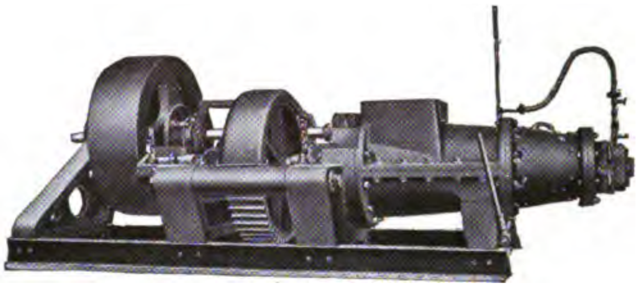
proofing Machinery

OHIO

The uses of the equipment we manufacture are described in the definition section under the following items:

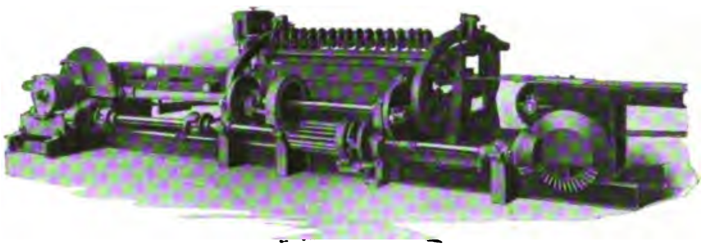
8, 23, 24, 32, 39, 45, 70, 77, 94, 95, 96, 97, 128, 133, 138, 149, 151, 152, 157, 163, 167, 171, 172, 173, 174, 175, 191, 192, 192A, 193, 200, 211, 214, 222, 227, 230, 243, 245, 301, 313, 335, 337, 453, 460, 499, 500, 521, 555, 563, 581, 608, 656, 661, 691.

Model GC Auger Brick Machine. Unusually accessible, with detachable and renewable thrust bearing. We build separate auger machines in 13 sizes and designs.



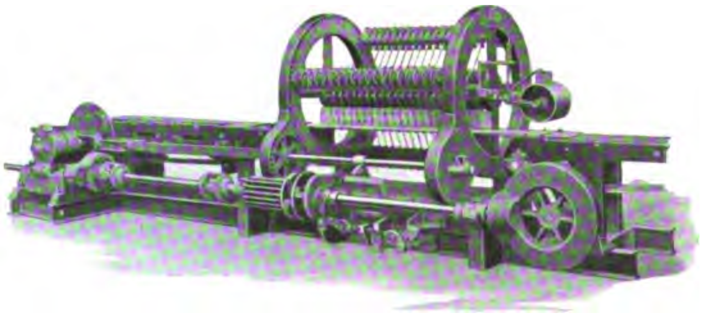
Model GC Auger Brick Machine

The Model T-60 Reciprocating Automatic Cutter solves the perplexing problem of the continuous production of true straight brick at high speed. Its design and construction give it several advantages in this respect over other types allowing the handling of large capacities while operating with a smooth, quiet movement.



Model T-60
Reciprocating Automatic Cutter

The Model C-20 Rotating Automatic Cutter has three distinctive features: Positive Mechanism, assuring sure action; Downward Shearing Wire Movement, producing sharp edges; and Slow Mechanical Movements, resulting in exceptionally low upkeep expense. The highest grade face brick are produced by this cutter—without re-pressing.



Model C-20
Rotating Automatic Cutter

A MODERN AND ECONOMICAL BRICK, TILE OR HOLLOW-WARE PLANT.

GANDY STITCHED COTTON DUCK BELTING

Gandy, the original stitched cotton duck belt, holds its place in the brick and clay industry on the strength of its high performance.

Its long-wearing qualities; its toughness and strength; its ability to withstand heat, cold, moisture, steam and chemicals, and its particular adaptability to practically all classes of service, whether driving, conveying or elevating, have made Gandy Belting the world's standard since 1880.

Gandy stitched cotton duck belting is made from long fibre cotton, woven on special machines by the patented Gandy process. The cotton duck is extra heavy, tightly woven, folded even and smooth and closely stitched with heavy twine. The belt is finally treated in a compound of pure oils, stretch is removed, and it is allowed to season.

Gandy Belt has great tensile strength; a tough, long-wearing structure that will hold up for years under hardest use, and the mechanical perfection which insures highest efficiency and satisfaction. Stretch troubles are avoided; it runs true; holds its shape; is pliable and delivers every bit of power.

Main Drive at the plant of the Crescent Brick Company, Eatontown, N. J. A 64 ft. 16 in. 8-ply Gandy Belt in continuous use for 13 years.

THERMO-GANDY

HIGH TEMPERATURE BELT

Thermo-Gandy is a high temperature belt, built especially to overcome unusual operating conditions. Its base is regular Gandy, specially prepared and treated with a black mineral impregnation. Thermo-Gandy Belt offers a great resistance to the action of water and some chemicals and acid fumes. It maintains its character operating in high temperatures. It presents a hard, flexible surface, very efficient and durable for carrying wet or heated materials or abrasives.

The superior qualities of Gandy and Thermo-Gandy Belting are especially recognized in the brick and clay industries, where these belts are at present being used for practically every purpose.

DRIVING Gandy Belt gives long service for all power transmission purposes, except in the relatively few cases where the pulley size is too small and where it should not be used. We have records of Gandy Belts on main drives, still in use and good condition after twenty, twenty-five years and even longer of continuous service.

CONVEYING The hard, long-wearing surface of Gandy Belt and its practical resistance to destructive agents make it unrivalled for all kinds of conveying. Moving wet clay, crushed stone, sand—working under cover or exposed—handling hot materials—in all classes of work a Gandy conveyor will hold up and deliver maximum service.

ELEVATING The hard, tough structure of Gandy Belt makes it particularly efficient on elevator installations where it holds securely the rivets and bucket fasteners.

For maximum belt service, both in years of use and satisfaction, equip with Gandy stitched cotton duck belt. Be sure the belt you buy is a Gandy Belt. There are three identifying marks—the green edge, the Gandy name and the Gandy trademark.

THE

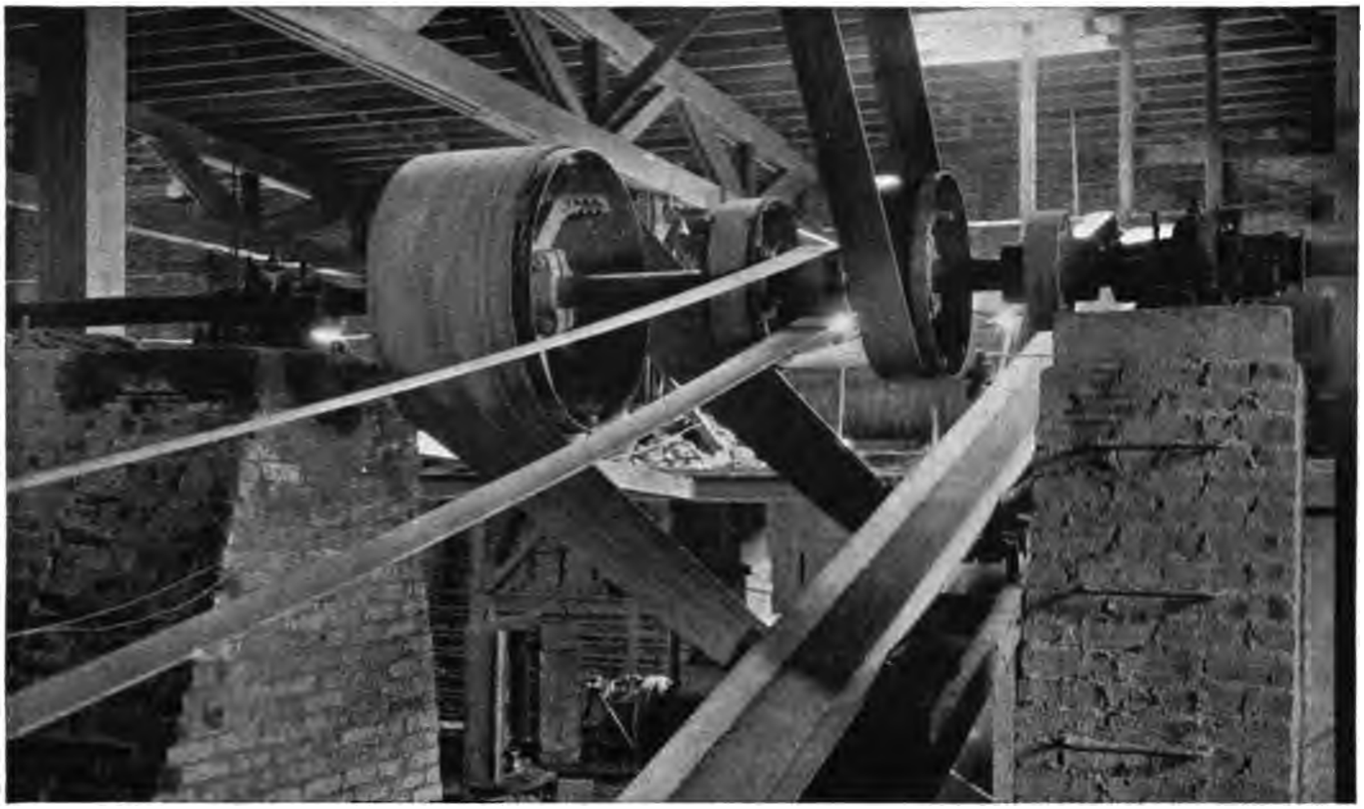
GANDY BELTING COMPANY

MAIN OFFICE and FACTORY, 726-40 PRATT STREET, BALTIMORE, MD.

NEW YORK: 36 Warren Street CHICAGO: 552 West Adams Street

A 250 ft. Gandy Belt conveyor installed in 1909 in the plant of St. Joseph Pressed Brick Co., St. Joseph, Mo., for moving ground shale.

Also see reference numbers:
41, 45, 151, 211, 245, 494



Goodyear Transmission and Conveyor Belts in the 100% Goodyear-belted plant of The Morey Clay Products Company, Ottumwa, Iowa

Copyright 1922, by The Goodyear Tire & Rubber Co., Inc.

The Best of Belts—and The G. T. M.

The brick and clay industry puts belting to a trying test, and only belts that are correctly designed, strongly built, and expertly specified to their work, can furnish efficient and economical operation in this exacting service.

Goodyear Belts have a reputation for powerful, trouble-free and long-wearing performance in this industry. They are designed right, built for durability, and specified to the job by the G. T. M.—Goodyear Technical Man.

In transmission duty, Goodyear Blue Streak Belts have the advantage of a tenacious friction surface, that delivers full power. They are pliable, adjusting themselves as they arc the pulleys, and making the most of the pulley contact. They are impervious to moisture, and resistive to the action of gritty dust.

For conveyor service, Goodyear Cougar Brand Conveyor Belts and other Goodyear Conveyor Belts are confidently recommended, according to the requirements of the work.

They are constructed especially to withstand the abrasive action of the varying sizes of clay, the manner in which it is delivered to the belt, and the resultant shifting of the load as it proceeds. They stand up to the reverse flexing action. They are impervious to moisture. Body, edges and cover are of special Goodyear stock and special Goodyear construction, insuring a long and serviceable life.

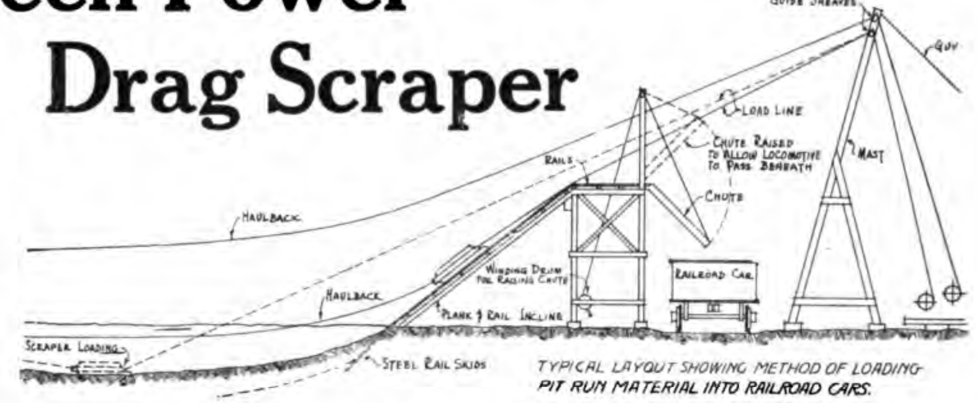
In all duty, transmission and conveying, on mud conveyors, pan emptying conveyors, and elevators, and in crusher and grinding pan service, Goodyear Belts give a quality of performance that has made their name known throughout the industry for low cost and good wear.

For specific information as to the service Goodyear Transmission and Conveyor Belts are giving in brick and clay plants, and the Goodyear Analysis Plan by which they are specified to their work, write to Goodyear, Akron, Ohio, or Los Angeles, California.

GOODYEAR

L. P. Green Power Drag Scraper

Patented



TYPICAL LAYOUT SHOWING METHOD OF LOADING PIT RUN MATERIAL INTO RAILROAD CARS.

The Power Drag Scraper will handle your stripping—

By using the Tower as shown in illustrations you can remove overburden a width of 200 ft. to 400 ft. and place same in a high pile well out of the way. In returning the scraper is lifted clear of the ground so as to insure a complete discharge in very sticky material.

Both the Initial Cost and Operating Costs Are Low—

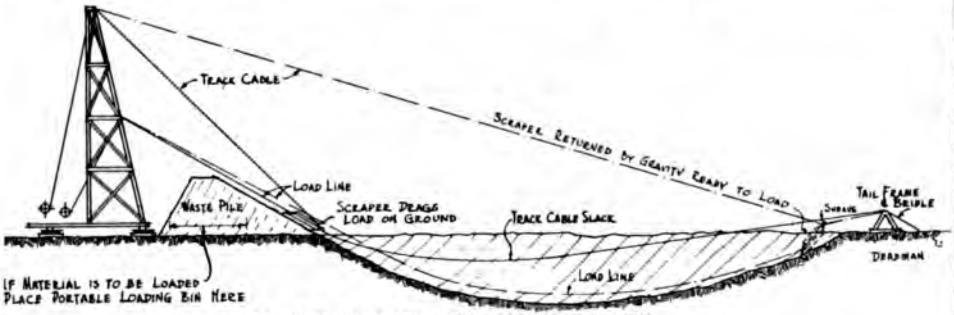
compared with other excavating machinery. Sizes range from 1/3 to 5 cu. yds., using either STEAM, ELECTRIC or GASOLINE Power, so that you can adjust your expenditures according to your needs.

Scraper can also be used to drag the overburden into the old workings, or to dig and convey your brick clay either to bin at the plant or to load cars.

The Scraper has a large handling capacity compared to its weight; still it is very substantially constructed in order to stand the most severe strain, and with teeth attached will dig very hard material.

Write in detail regarding your excavating problems

L. P. GREEN, Lumber Exchange Bldg., CHICAGO


TRACK CABLE
SCRAPER RETURNED BY GRAVITY READY TO LOAD
LOAD LINE
WASTE PILE
SCRAPER DRAGS LOAD ON GROUND
TRACK CABLE SLACK
SHEAVE
TAIL FRAME & BRIDLE
DEADMAN
LOAD LINE
IF MATERIAL IS TO BE LOADED PLACE PORTABLE LOADING BIN HERE

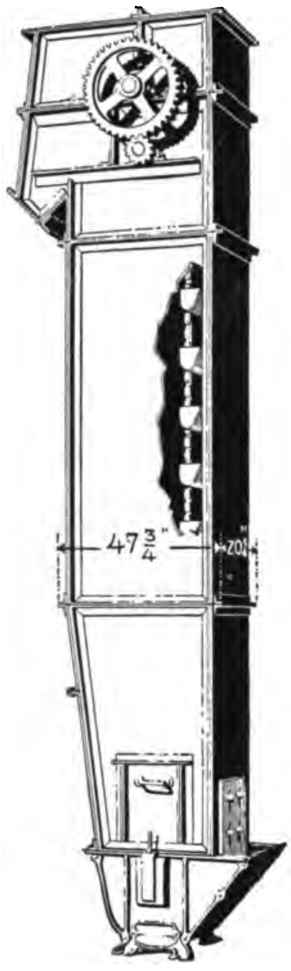
TYPICAL LAYOUT SHOWING USE OF PORTABLE TOWER

GRUENDLER PATENT CRUSHER & PULVERIZER COMPANY

928 North Main Street :: :: :: SAINT LOUIS, MO.

PRODUCTS

Crushers, Roll, Jaw and Swing Hammer type, Revolving and Shaker Screens, Elevators and Conveying Machinery, Pulverizers with Air Separation.



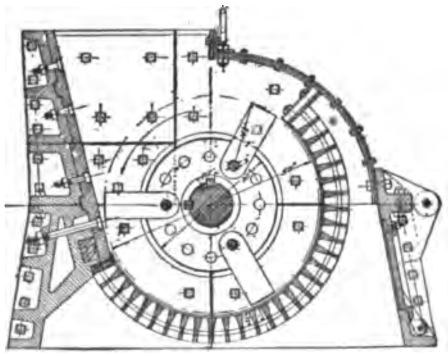
The Above Illustration Shows The Gruendler Standard Elevator manufactured in all Sizes.

GRUENDLER Machines Are Specially Adapted

for crushing and pulverizing to desired fineness such materials as Shale, Clay, Fire Clay, Gypsum, Coal, Brick Bats, etc.

Description

As shown in the illustration below, the Gruendler consists of a series of octagonal discs, each separately punched to receive from 4 to 16 swinging hammers and all mounted on a common shaft over grate bars of a special design. The discs are revolved at a speed varying from 400 to 1400 r. p. m. and when it is considered that the average size crusher contains 48 separate swing hammers, each of which strikes a blow at every revolution, it is evident that the number of impacts or blows delivered each minute is tremendous. Because it is possible through the Gruendler method of disc punching to adjust the hammers to practically any required crushing distance from the grate surface, this crusher provides the maximum range for finished sizes and it is therefore equally as efficient in fine grinding as when it is required only to break down a product ahead of a finishing mill.



Cut No. 2 Cross-Section View

Cut No. 3 Heavy Type Machine

Manufactured in capacities from 5 to 500 tons hourly.

Important Facts About Gruendler Crushers and Pulverizers

No. 1. Greatest capacity of most uniform product per H. P. over any dry wet pans or any other type pulverizers.

No. 2. Most reliable—no shut downs.

No. 3. Simplicity, and most durable, will give longest service.

No. 4. Ball bearing or ring oiling bearings.

No. 5. Low starting Torque—smooth running.

No. 6. Guaranteed to handle foreign material without damage to machine.

No. 7. Repairs practically nothing. .0625 per ton product.

No. 8. Guaranteed to give rated capacity.

No. 9. Steam jacketed to prevent choke up on wet material.

No. 10. Requiring very little space—compact.

Write for Further Details

We maintain an Engineering Department that will be glad to co-operate with you in solving your problems. You will find our service to be the very highest quality. No job too small or too large for us to handle.

The Hadfield-Penfield Steel Co.
BUILT RIGHT RUN RIGHT
BUCYRUS OHIO. U.S.A.

The American Line of Clay Working Machinery

Nearly three-quarters of a century of experience is back of the American Line of Clay Working Machinery. It includes every machine or appliance a Clay worker needs. Design, Construction and Service are prime features of our organization. Tell us your problems or your needs. Correspondence solicited. These are only a few of our line. Send for our big Clay Workers' Encyclopaedia. It's free to Clay Workers.

"American" No. 57 Nine-Foot Dry Pan

"American" No. 290 Auger Machine

"American" No. 302 Pug Mill

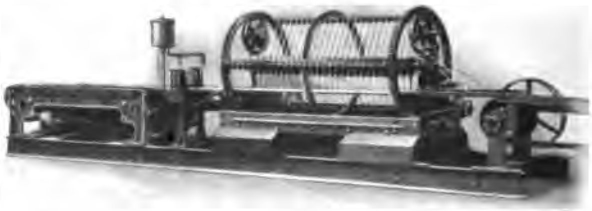
"American" No. 292 Repress

"American" Dump Car

"American" Waste Heat Dryer Outfit

"American" Haigh Kiln

"American" Sewer Pipe Press



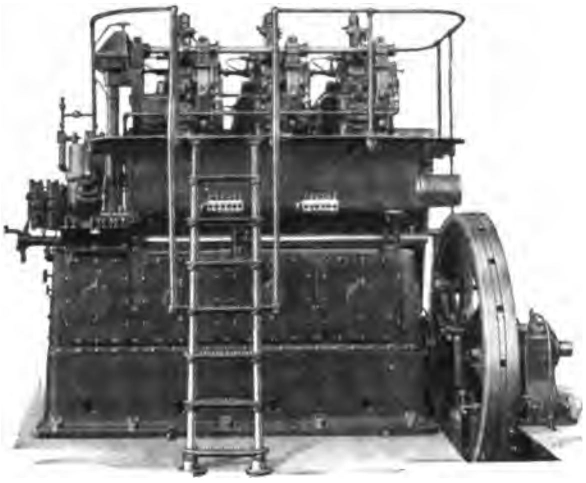
"American" No. 350 Cutter

THE HADFIELD-PENFIELD STEEL CO., BUCYRUS, OHIO, U. S. A.
Formerly The American Clay Machinery Co.

The Hadfield-Penfield Steel Co.
BUCYRUS OHIO. U.S.A.

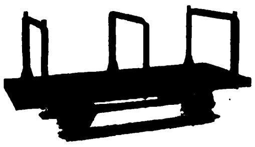
BUILT RIGHT RUN RIGHT

No matter what your want may be in the equipment of a plant for manufacturing Clay Products, we are able to assist you. Our many years of experience has given us a knowledge of the necessities of construction and we are able to give the Clay Products Manufacturer equipment which will eliminate many clay plant troubles and give him the maximum amount of production at a minimum of cost. Get our big catalog. Feel at liberty to write us on any clay plant subject. We want to help make Clay Plants Successful.



"American" Diesel Oil Engine

"American" Gasoline Locomotive



"American" Dryer Cars

"American" Rotary Dryer

"American" Transfer Cars

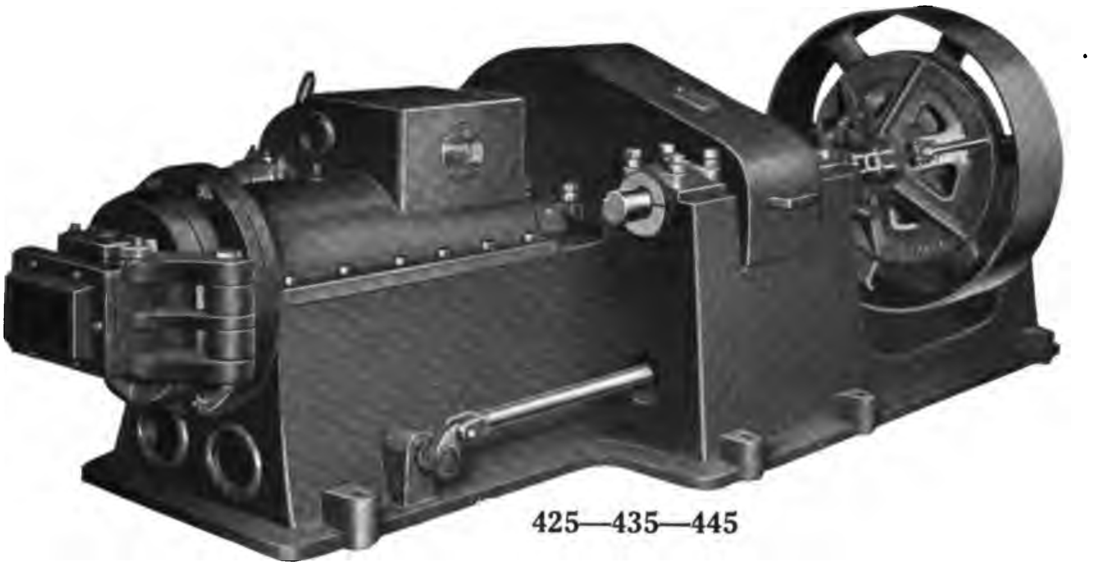
"American" No. 387 Pug Mill

"American" No. 727 Barrow

"American" No. 393 Winding Drum

THE HADFIELD-PENFIELD STEEL CO., BUCYRUS, OHIO, U. S. A.
Formerly The American Clay Machinery Co.

EVERYTHING



425—435—445

For Brick or Hollow Products

The thoroughbreds of auger machines. Three machines designed on the same principle, differing only in size and capacity, and equally suitable for manufacturing brick or hollow clay products.

The entire base of the machine, including the outboard bearing, is cast in one piece, a patented feature. This rigid construction, which is impossible to get in a frame of girder construction, securely holds all shafts and gears in perfect alignment. No moving parts of the machine extend beyond this base. All parts lift out upward. The alignment of the bearings cannot be disturbed, a very important feature in making repairs.

Each machine has two thrusts on the auger shaft, a marine and a floating end thrust, either of which is capable of taking the total thrust load of the machine. All bearings are ring or chain oiled. Shafts are large in diameter, gears wide in face and running in oil. The barrel is fitted with removable liners.

Strength, simplicity and practical elimination of vibration are the outstanding features of these machines.

Pug Mills
Disintegrators
Crushers
Clay Feeders
Hoists
Dump Cars
Represses, Automatic
Represses, Hand
Screens
Roofing Tile Presses
Dryer Cars
Conveyors
Turntables
Gas Producers
Continuous Kilns
Periodic Kilns
Elevators
Trackage

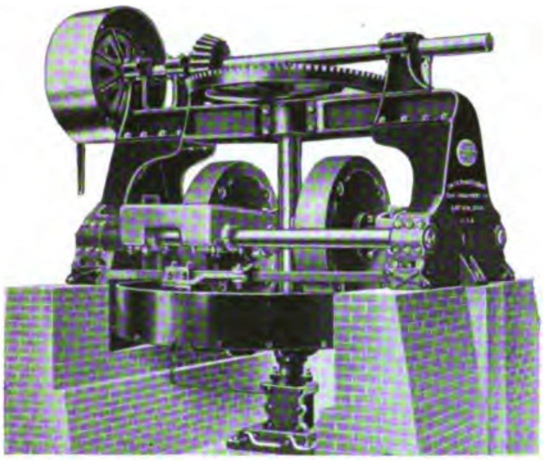
Type 470 Combination Machine

International Clay

DAYTON, OHIO

New York **Toronto,**

CLAYPIT to CARS



Dry and Wet Pans—Sizes 5 to 10 ft.

New 10- and 9-ft. PANS

POINTS OF SUPERIORITY. Low, massive frames bolted to foundation in triangular alignment. Wearing plates raised an inch above screen plates, preventing breakage of screen plates. Bottom disc belled out, forcing all clay in center of pan under the mullers. Mullers grouped close to center, giving largest possible screening surface. Three bearings on drive shaft, two being grouped for pulley support. Spherical bronze step bearing, assuring perfect alignment and bearing surface at all times.

Illustration shows independent muller drive.

International Automatic Cutting Tables have a continuous motion reel traveling at constant speed. This means less jarring than when a periodic motion is employed, and consequently long life.

We build a complete line of Semi-Automatic Cutters, Hand Cutters and Hollow Ware Cutters.

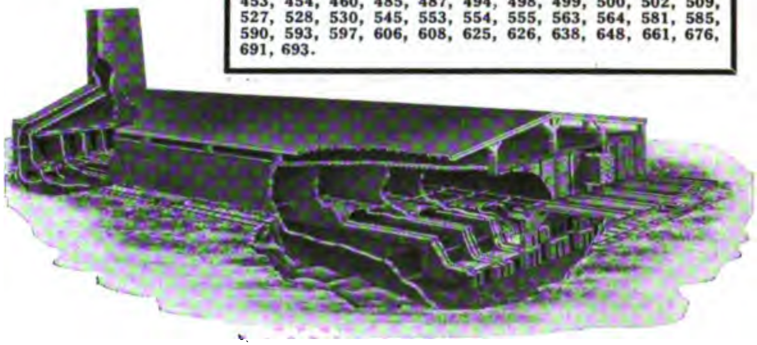
Type 510 Automatic Cutter.

International Metallic Radiation Dryer

A good dryer is more than an assembly of iron and brick work. International Dryers have incorporated in their design principles of atmospheric control and heat regulation based on years of experiment, which insure the best results for the clay manufacturer. New, improved metallic radiators give a greatly increased radiating area over previous construction. Designed to burn coal, wood, producer or natural gas, or oil.

We also build waste heat dryers and combinations of waste heat and radiation dryers.

Additional information will be found under the following references:
5, 8, 20, 23, 24, 29, 30, 32, 39, 45, 47, 55, 56, 70, 77, 94, 95, 96, 97, 98, 101, 104, 115, 133, 138, 149, 151, 154, 158, 167, 169, 171, 172, 173, 174, 175, 176, 191, 192, 193, 200, 213, 214, 217, 221, 222, 227, 229, 230, 234, 243, 247, 255, 256, 259, 260, 271, 284, 295, 297, 313, 335, 337, 365, 372, 373, 377, 383, 384, 388, 393, 394, 395, 396, 397, 398, 399, 404, 428, 431, 433, 452, 453, 454, 460, 485, 487, 494, 498, 499, 500, 502, 509, 527, 528, 530, 545, 553, 554, 555, 563, 564, 581, 585, 590, 593, 597, 606, 608, 625, 626, 638, 648, 661, 676, 691, 693.



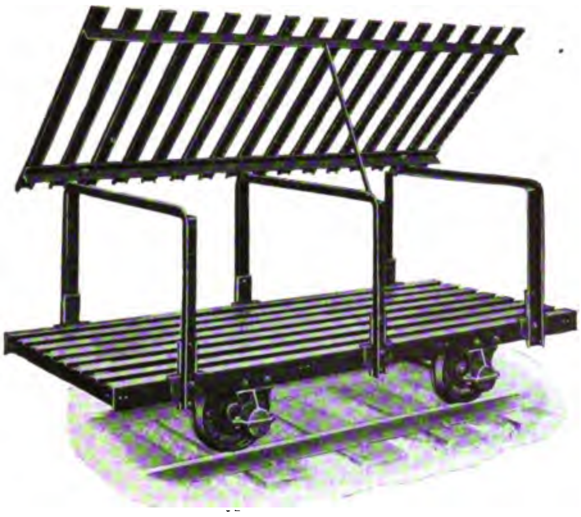
BERG PRESS
Two and Four Mould
Berg Automatic Dry Presses
Also Hand Power Presses

Machinery Co.

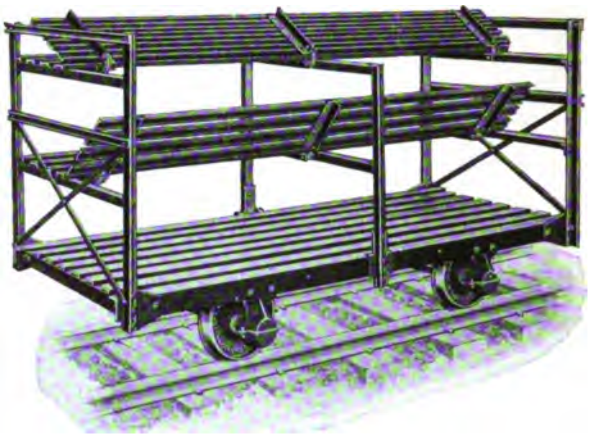
U. S. A
Canada

Pittsburgh

DRYER CARS



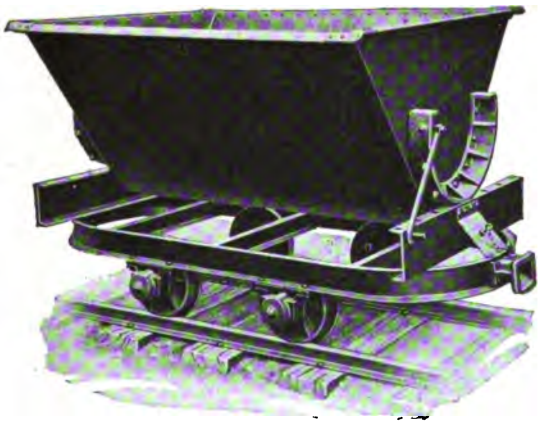
Type G



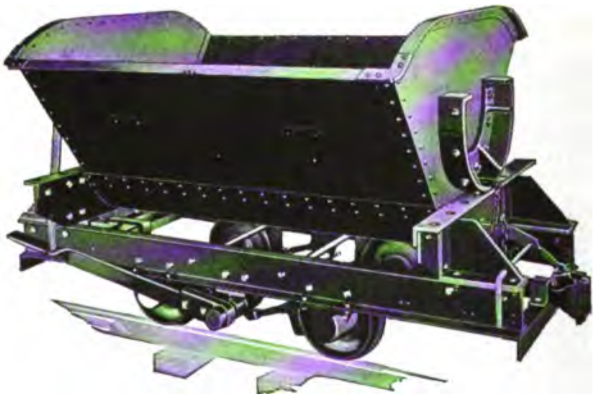
Type O

International Dryer Cars have for years set a standard for construction and design. The bearings are flexible and adjust themselves to irregularities in the track and even to sprung axles. The wheels are solid with wide tread. Gussets are pressed steel with a flange carrying the weight of the upper decks. Single, double and triple deck cars with or without deck slats are built as a standard or to your specifications.

DUMP CARS



Type 50
A well-built car for average use



Type 60
Heavy Duty Car—1 to 4 yd. capacity

A Complete Line of Industrial Cars, Portable Trackage, Rails, Switches, Turntables

Years of experience in completely designing and equipping clay plants enables us to specify and build Dump Cars particularly adapted to your conditions. New car catalog on request.

International Clay Machinery Co.

DAYTON, OHIO, U. S. A.

LINK-BELT COMPANY

PHILADELPHIA
New York............Woolworth Bldg.
Boston 9................49 Federal St.
Pittsburgh..............1501 Park Bldg.
St. Louis......Central Nat'l Bank Bldg.
Buffalo.............547 Elliott Square

CHICAGO
Wilkes-Barre.......2d Nat'l Bank Bldg.
Huntington, W. Va. Robson-Prichard Bldg.
Cleveland..............429 Kirby Bldg.
Detroit...........4210 Woodward Ave.
Kansas City, Mo....306 Elmhurst Bldg.

Seattle................820 First Ave., S.
Portland, Ore.......First and Stark Sts.
San Francisco...........168 Second St.
Los Angeles......163 N. Los Angeles St.
Denver...................Boston Bldg.
Lindrooth, Shubart & Co.

INDIANAPOLIS
Louisville, Ky.............Starks Bldg.
Frederick Wehle
New Orleans......504 Carondelet Bldg.
C. O. Hins
Birmingham, Ala..720 Brown-Marx Bldg.
S. L. Morrow

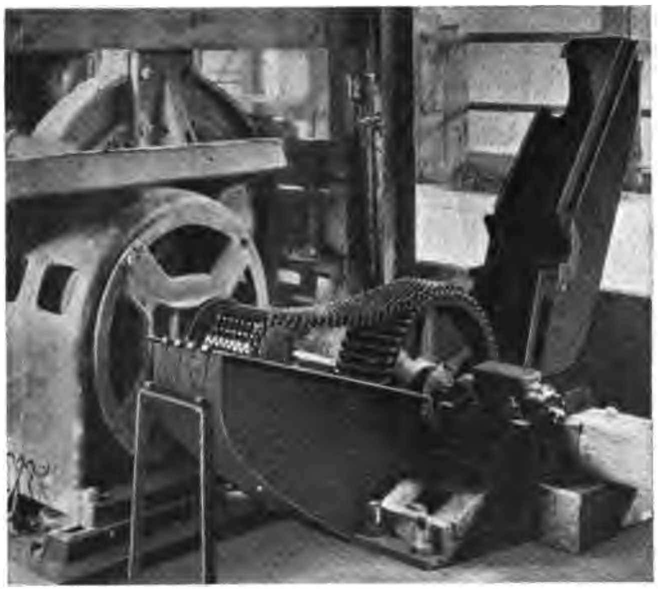
In Canada....................Canadian Link-Belt Co., Ltd., Toronto and Montreal

H. W. CALDWELL & SON CO., CHICAGO, 17th St. and Western Ave.
NEW YORK, Woolworth Building
DALLAS, TEXAS, 709 Main St.

Elevating, Conveying and Power Transmitting Machinery

The uses of the equipment we manufacture are described under items numbered—
20, 26, 39, 44, 49, 70, 76, 77, 86, 95, 96, 98, 98A, 98B, 98C, 99, 100, 101, 104, 113, 115, 116, 138, 140, 149, 150, 151, 152, 152A, 153, 153A, 154, 155, 156, 157, 158, 163, 164, 167, 169, 170, 171, 172, 211, 212, 213, 242, 243, 244, 245, 250, 256, 280, 301, 317, 335, 342A, 369, 370, 409A, 457, 494, 500, 501, 553, 554, 555, 556, 564, 570, 599, 617, 626, 667.

Link-Belt Silent Chain for the Efficient Transmission of Power


Link-Belt Silent Chain Drive operating grinding pan.
Standard Refractories Co., Claysburg, Pa.

The Link-Belt Silent Chain Drive furnishes the most commercially efficient and technically sound form for the transmission of power. It is "Flexible as a Belt—Positive as a Gear—More Efficient than Either."

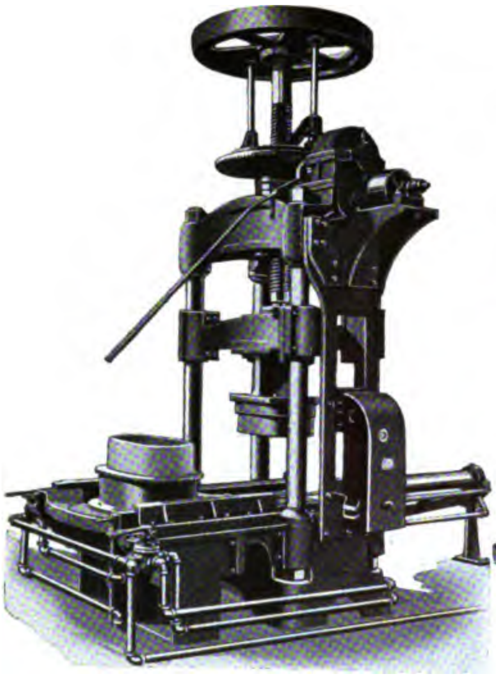
The superiority of Link-Belt Silent Chain is proved by the vast number of drives in use today after years of severe duty. They grow old in service because they possess lasting qualities.

Over fifty clay plants have adopted this drive for operating fans, lineshafts, pans, pug mills, washers, agitators, glaze mills, etc.

Link-Belt Silent Chain is practically a flexible gear. It cannot slip. Tension is on the pulling side of the chain only; hence journal friction is much less than with belt drives.

No power is lost by reason of bearing friction; 98.2% of the energy of the motor is transmitted to your shaft or machine to perform useful work. The drive is not affected by atmospheric conditions, operating equally well in hot, cold or damp places; it permits economy of space because you are able to arrange for shaft centers to suit the convenient location of your driving unit. You do not need the long centers required for flat belt, or the fixed short centers required for gears. It combines in one drive the best points of leather belts and cut gears, minus their disadvantages. Enclosed in our oil-retaining dust-proof casing, the drive is protected from dust, insures safety to workers, and requires practically no attention. You can learn all about it by writing for 128-page Price-List-Data-Book No. 125. It contains information for every man who is interested in the economical transmission of power. Also send for Book No. 310, illustrating clay plant drives.

Seggar Room



Seggar Press No. 2

Dry and Wet Pan

Pug Mill

Seggar Press No. 1

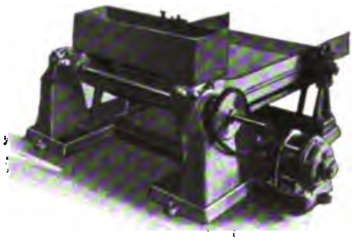
Sliphouse

Glaze Agitator

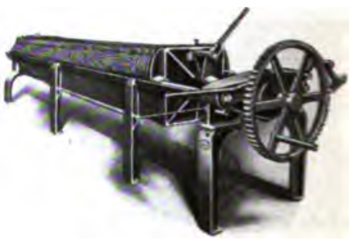
Blunger

Clay Agitator

Pump



Lawn



Filter Press

As Equipped by

The Mueller Machine Co., Inc.

Manufacturers of Modern Clay and Tile Machinery

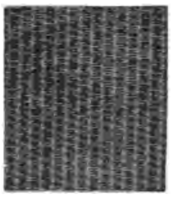
Trenton, N. J.

Everything in Wire Screens

Sign of

NEWARK

Quality


Actual Filter Cloth Mesh

Magnified Section of Filter Cloth

Wire Cloth, All Grades
Fine and Extra Fine
Filter Cloths (Metallic)
Centrifugal Cloths
Bolting Cloths

Testing Sieves, U. S. Standard
Chemists' Sieves
Cement Sieves
Foundry Riddles

Brass
Nickel

Copper
Steel
Gold

Bronze
Monel Metal
Platinum

Phosphor Bronze
Silver

NEWARK
Metallic Filter Cloth

We are the originators of this grade of metallic filter cloth.

We invite close inspection of our *several* grades of this material for filtration work and centrifugal linings.

Note the character and even texture of the weave; strength and durability are imparted to the fabric. It has a double surface, is extra strong, and is readily cleaned.

One section shows the exact size of mesh, while the other section shows the cloth magnified—note the spiral overlap in the weave. "NEWARK" Metallic Filter Cloth is for use in all makes of filter presses in place of cotton, duck, wool, jute or other filtering mediums—and will stand strong solutions which shorten life of others.

PRICE LIST, TESTING SIEVES

Brass Frames **U. S. Standard Sieve Series**

Sieve Number	Opening		Wire Dia.		5" Dia.	6" Dia.	8" Dia.	10" Dia.	12" Dia.
	MM	Inch	MM	Inch					
2½	8.00	.315	1.85	.073	$2.50	$2.80	$4.00	$5.35	6.50
3	6.72	.265	1.65	.065	2.50	2.80	4.00	5.35	6.50
3½	5.66	.223	1.45	.057	2.50	2.80	4.00	5.35	6.50
4	4.76	.187	1.27	.050	2.35	2.60	3.75	5.00	6.10
5	4.00	.157	1.12	.044	2.35	2.60	3.75	5.00	6.10
6	3.36	.132	1.02	.040	2.35	2.60	3.75	5.00	6.10
7	2.83	.111	.92	.036	2.35	2.60	3.75	5.00	6.10
8	2.38	.094	.84	.033	2.35	2.60	3.75	5.00	6.10
10	2.00	.079	.76	.030	2.25	2.50	3.55	4.70	5.70
12	1.68	.066	.69	.027	2.25	2.50	3.55	4.70	5.70
14	1.41	.0557	.61	.024	2.25	2.50	3.55	4.70	5.70
16	1.19	.0468	.54	.021	2.25	2.50	3.55	4.70	5.70
18	1.00	.0394	.48	.0187	2.25	2.50	3.55	4.70	5.70
20	.84	.0331	.42	.0165	2.10	2.35	3.30	4.40	5.40
25	.71	.0278	.37	.0146	2.10	2.35	3.30	4.40	5.40
30	.59	.0234	.33	.0129	2.10	2.35	3.30	4.40	5.40
35	.50	.0197	.29	.0113	2.10	2.35	3.30	4.40	5.40
40	.42	.0166	.25	.0098	2.25	2.50	3.55	4.70	5.70
45	.35	.0139	.22	.0085	2.25	2.50	3.55	4.70	5.70
50	.30	.0117	.188	.0074	2.25	2.50	3.55	4.70	5.70
60	.25	.0098	.162	.0064	2.25	2.50	3.55	4.70	5.70
70	.21	.0083	.140	.0055	2.35	2.60	3.75	4.95	6.10
80	.177	.0070	.119	.0047	2.50	2.75	4.00	5.00	6.50
100	.149	.0059	.102	.0040	2.85	3.15	4.70	6.50	8.30
120	.125	.0049	.086	.0034	3.00	3.30	5.00	7.00	9.05
140	.105	.0041	.074	.0029	3.35	3.75	5.70	8.05	10.45
170	.088	.0035	.063	.0025	4.00	4.40	7.00	10.00	13.35
200	.074	.0029	.053	.0021	4.30	4.75	7.60	10.95	14.75
230	.062	.0025	.046	.0018	4.95	5.50	8.80	12.80	17.30
270	.053	.0021	.041	.0016	6.35	6.85	11.20	16.50	22.55
325	.044	.0017	.036	.0014	11.75	14.00	18.25	28.00	32.25
Pan and Cover					2.25	2.50	3.00	3.50	4.00

Nest of U. S. Standard Testing Sieves

Newark Wire Cloth Company

Newark, N. J. **U. S. A.**

NEW YORK BELTING & PACKING CO.

NEW YORK................91-93 Chambers St.
BOSTON..........................65 Pearl St.
CHICAGO..............124-126 West Lake St.
PHILADELPHIA..............821-823 Arch St.

NEW YORK BELTING & PACKING CO.
FOUNDED 1846
INCORPORATED 1856

PITTSBURGH...................420 First Ave.
ST. LOUIS.................218-220 Chestnut St.
SALT LAKE CITY................313 Felt Bldg.
SAN FRANCISCO...............519 Mission St.

RUBBER BELTING, HOSE AND PACKING

PRODUCTS

Belting. Conveyor—Power Transmission.

Hose. Water—Suction—Steam—Fire Protection—Acetylene Welding.

Packing. Sheet Rubber—Superheat Sheet—Piston—Hydraulic—Valve Stem—Gaskets.

Pump Valves.

TEST SPECIAL TRANSMISSION BELTING

The highest quality belting, for all power transmission purposes.

Made from specially woven cotton duck of great tensile strength, the plies of which are inseparably bonded with a rubber friction that retains its adhesion under the hardest service. Waterproof, flexible, strong and durable. Withstands exposure to dust, grit and moisture. Has a friction surface which gives the maximum pulley grip. Test Special Rubber Belting shows economy in initial cost and its freedom from stretch is a protection against trouble in operation.

TEST SPECIAL Belting driving hot saw in plant of Tacony Steel Co., Philadelphia

INDESTRUCTIBLE CONVEYOR BELTING

Gives maximum service under conditions that make the use of ordinary belting more costly in the long run.

The cotton duck used in Indestructible Conveyor Belting has great tensile strength to withstand excessive strains with a wide margin of safety. The rubber friction uniting the plies of duck is particularly strong and tenacious with a remarkable ageing quality. As the life of a belt is usually the life of the rubber cover, great care is exercised in selecting and compounding the stock for the cover of Indestructible Belts. The rubber cover can be relied upon to retain its strong adhesion to the fabric, and remain pliable throughout the life of the belt.

Indestructible Conveyor Belting

HOSE

Hose for all classes of service, steam, water, air, etc., built on the INDESTRUCTIBLE principle; inner plies of wrapped duck over which is woven a fabric jacket of strong cotton yarns.

Indestructible Hose

PACKING

Packing for all purposes, steam, air, hot or cold water, acid, oil, chemicals, etc. Write for Packing Catalog.

INDESTRUCTIBLE White Sheet Packing is a rubber packing for general use. FIRO Sheet Packing for superheat service. Cobbs' Piston Packing for pressure to 150 pounds.

PUMP VALVES

Rubber Pump Valves for hot or cold water, and a variety of other uses and pressures.

CATALOGS

We issue a general catalog covering all principal products, and special catalogs on the following: Test Special Belting, Packing, Pump Valves.

"HURRICANE" DRYERS

AUTOMATIC STOVE ROOM for chinaware. Is uniformly drying ware, with even shrinkage and practically no spoilage, in from 60 to 90 minutes. The number of moulds required is reduced from 50 to 75 per cent. Cost of handling is greatly reduced, and the life of the moulds is lengthened considerably. The floor space required is small compared to the work turned out.

EVERY clay products manufacturer who is using "HURRICANE" Dryers will attest to their ability to give long, uninterrupted Service, producing first-class ware, quickly and at low cost.

"HURRICANE" Service consists of a systematic survey of the conditions characteristic of your plant, scientific design and construction of equipment best adapted to those conditions, actual supervision of erection of the machinery in your plant, which includes putting it into operation to meet the desired results in production and quality of ware.

Our Service does not end after the installation. We are always prepared to co-operate with you regarding any problem that may come up, whether in connection with the Dryers already installed, or any new drying proposition.

"HURRICANE" SERVICE means SATISFACTORY SERVICE
Write for Details. State Material and Quantity.

AUTOMATIC MANGLE. Dipped ware can be dried in from 20 to 30 minutes. Finger marking and scarring is eliminated. The ware, after being dipped, is placed on the conveyor trays, and is delivered dry at the other end of the machine, without further handling. Steam and power consumption is materially lowered.

TUNNEL TRUCK DRYER for High Tension Electric Insulators. This ware is being dried in 48 hours, with absolute uniformity. It previously took from 10 days to two weeks. This machine can be depended on to turn out the ware in fine condition, precisely on schedule.

CONTINUOUS CONVEYOR DRYER, illustrated on the left, is used for Spark Plugs, Cores, Electrical Porcelain, Clay Rolls, Filtered Leaf Clay Cakes, etc. This machine, as do all the other types, features positively controlled humidity and temperature conditions, which successfully dries all kinds of ware, with no cracking or warping, irrespective of the size of the ware.

STILLAGE TUNNEL DRYER, shown here on the right, is used for Dry Press Ware. Makes decided reductions in labor cost. The ware is not rehandled from the time it is pressed until it is ready to be fired. Automatic control of temperature and humidity assures quick, safe drying.

Please also refer to items numbered 94, 149, 216, 218, 219, 220, 221, 225, 228, 229, 230, 255, 354, 424, 494, 618.

The Philadelphia Drying Machinery Company
3351 Stokley Street Philadelphia, Pa.

"Proctor" DRYERS

FOR ALL CLAY PRODUCTS

Automatic Conditioning Machine for Insulators in Moulds

Tunnel-Truck Humidity Dryer for Electrical Porcelain, Chemical Stoneware, Tile, etc.

Automatic Conveyor Dryer for Pressed Porcelain, Spark Plugs, etc.

Automatic Stove Room for General Ware

Rack Dryer for Sanitary Ware

Automatic Mangle for Dipped Ware

Automatic Conveyor Dryer for Saggers

Truck Dryer for Saggers

Tunnel-Car Dryer for Brick and Heavy Clay Products.

"Proctor" Drying Machines of various types are successfully and economically drying Electrical Porcelain, Sanitary Ware, General Ware, Chemical Stoneware, Saggers, Spark Plugs, Clay Rolls, Tile, Refactories, Brick, Glass Pots and practically every other Ceramic Product

The uses of the equipment we manufacture are described under the following numbered items:

216	219	221	227	229	424
218	220	225	228	230	618

Consult our Special Ceramic Drying Dept. on any drying problem. Send for catalogues, mentioning your products

PROCTOR & SCHWARTZ, INC.
PHILADELPHIA

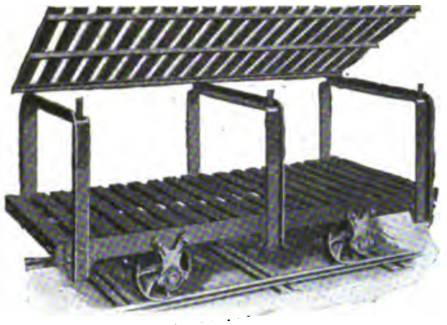
FRANK H. ROBINSON

PITTSBURGH, PA.

Dryer Cars and Clay Working Equipment

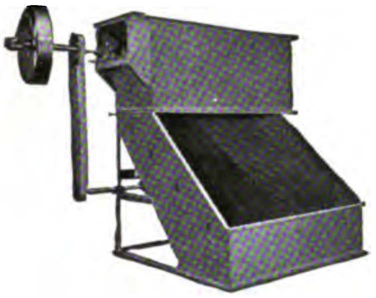
DRYER CARS

Standard and special types of single, double and triple deck cars, and rack cars with plain or flexible roller bearings.



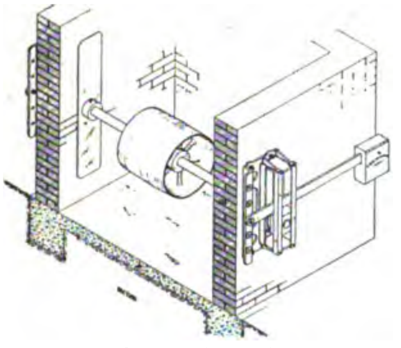
Correct design and high quality workmanship make for easy running and satisfactory service.

ROTA VIBRA SCREEN



A vibrating wire cloth screen, mechanically operated, equipped with auxiliary rotating screen, or scalper, to take out coarse tailings. Positive in action and low in maintenance cost.

ELEVATOR TAKE-UP



This take up is used in built up bin of brick or concrete. Outside bearings provide accessibility, inside dust plates insure protection. Weight keeps belt tight at all times. Furnished with any diameter or face of pulley desired.

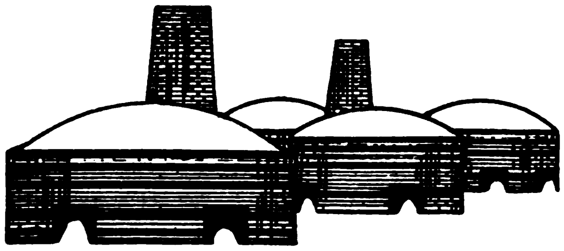
The Other Units of

THE ROBINSON LINE

Transfer cars—including a new design with Hyatt roller bearings in flexible housing, Repress and Dry Press Dies, Barrows, Steel Rails and Portable Track, Wood Body Clay Cars, Crushers, Wire Rope, General Supplies and Repairs.

KILN BANDS

Our kiln bands are giving satisfactory service in many installations.



Made in a variety of designs to meet particular needs.

RADIATED HEAT DRYER

Built with Radiating Plates in floor of tunnel, insures rapid and economical drying. No machinery of any kind required to operate. Radiating Plates furnished for old dryers.

CLAY FEEDER

Substantially built, insuring freedom from constant repair. Increases capacity, improves quality, reduces strain on machinery. Built in three sizes.

DUMP CARS

Lakewood V Body Dump Cars—the standard dump car for clay plants. Built at Cleveland by The Lakewood Engineering Company. Sturdy, easy to handle, dumps clean.

RODGERS

YOUR MONEY'S WORTH

in service, equipment, results and satisfaction—that's what you get when you transact business with the L. E. Rodgers Engineering Co.

You are *served* personally by our Mr. L. E. Rodgers, designer of

RODGERS WASTE HEAT DRYERS,

every detail of your drying problem being worked out under his personal supervision.

You receive, for your money, *equipment* better than which it is impossible to build.

Rodgers designed and equipped Dryers *always* give *results* and results mean *satisfaction.*

Whether building a new plant, or remodeling an old one, if you want your

MONEY'S WORTH

you can get it by intrusting your work to the

L. E. RODGERS ENGINEERING CO.

Waste Heat Dryer Specialists
Designers of Complete Clay Working Plants
Largest Manufacturers of Brick Drying Equipment in the United States

Sole Licensee

HARROP CONTINUOUS TUNNEL KILN

30 North LaSalle Street :: :: CHICAGO

RODGERS

The Schaffer Engineering & Equipment Co.

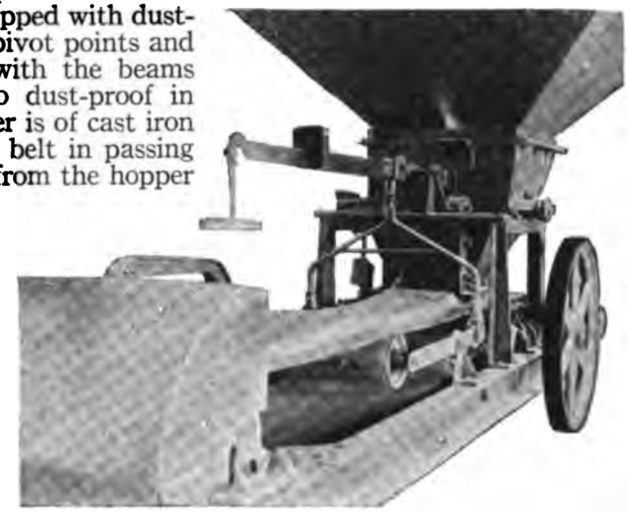
2828 Smallman Street, Pittsburgh, Pa.

THE POIDOMETER

The Poidometer is a precision machine, designed and built to feed clay, and other materials—by weight—in a steady, uniform, constant stream. With the Liquidometer attachment, which feeds water in proportion to clay, the Poidometer becomes an automatic pugger. It eliminates the man with the hose. But of greater importance, it produces a uniformly tempered column, the like of which it is humanly impossible to duplicate.

Construction

The Poidometer is self contained. Mounted on a substantial steel frame, all bearings are of highest quality and the weighing apparatus is of the best construction, being equipped with dust-proof ball bearings, and all pivot points and knife edges in connection with the beams are case hardened and also dust-proof in their enclosures. The hopper is of cast iron and is so arranged that the belt in passing under it, pulls the material from the hopper instead of the hopper spilling the material onto the belt. The regulating gate on the hopper has double knuckle joints and is connected with the walking beam by case hardened pivot points mounted, and case hardened knife edges. Hopper gate operates absolutely free—no friction. The roller under the center of the belt (which primarily functions by supporting the belt with its load in causing a compensating mechanical reaction against the scale beam) is ball bearing.



Installation

The location for the Poidometer is between the clay bin and the pugmill. Ordinarily, the opening in the bin is enclosed with the Poidometer hopper, in which revolves a shaft with blades, constantly agitating the material. The clay flows through the regulating gate and over the belt to the pugmill. The water is discharged into the pugmill simultaneously with the clay.

Operation

The starting of the Poidometer automatically starts delivery of the clay and water to the pugmill. Should the clay bin run empty, the Poidometer and the discharge of water automatically cease. When the missing material is supplied, automatically the Poidometer starts, and delivery of the clay and water is resumed. The same is true of the water supply. If it fails, the Poidometer automatically stops until it is supplied again.

The Poidometer scale beam is calibrated in pounds, equivalent to the weight per running foot of belt. The tons desired per hour are reduced to pounds per running foot of belt, to which the weight on the scale beam is then set. Unless each foot of belt contains the weight called for on the scale beam, the Poidometer will automatically refuse to operate. Nor can it be crowded—it will automatically refuse to take more than the weight called for on the scale beam. The capacity can be increased or decreased by shifting the scale beam weight. This can be locked in place, if desired. The Productometer gives a reading at any time of the weight that has passed over the belt.

Batch Weigher Attachment

This attachment permits the use of the Poidometer in batch operations and also permits of bulk loading or the delivery or a predetermined specified weight of material.

Accuracy

The accuracy of the Poidometer is almost unbelievable. Exhaustive tests covering a wide variety of installations have indicated an accuracy of practically 100%.

Indispensable for Compounding or Blending

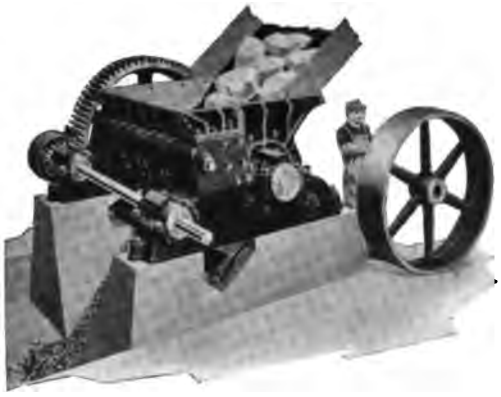
Where two or more materials are to be compounded, Poidometers produce a perfect mixture. Specked brick are being most successfully manufactured where Poidometers blend the manganese and clay.

Sizes and Capacities

Poidometers are manufactured in three sizes, with a range in capacities from the fraction of a pound to five tons per minute. The belt lengths are in two standard sizes.

We maintain a complete staff of experienced engineers for the purpose of studying your conditions. Without obligation to you, they are at your service.

Write for Our Catalog and Descriptive Literature



CRUSHERS

SINGLE ROLL TYPE — For the primary reduction of clay, shale, phosphates lime, rock, coal, etc.

An exceptionally well designed and well built unit of high efficiency.

THEY CRUSH

DRY PANS

HEAVY—husky—slow speed—low maintenance cost — reduction units for pulverizing clays, shale, etc.

Furnished in standard design or built special to suit specific needs.

THEY REDUCE

WET PANS

FURNISHED in Standard or Duplex type. For tempering or grinding and tempering clays and shale. Providing the most efficient method of mechanically pugging raw materials under pressure.

THEY TEMPER

THE LINE OF HIGHEST EFFICIENCY

The Stevenson Company

General Office and Works
WELLSVILLE, OHIO

Bulletins on request

Western Sales & Engr. Office
Monadnock Building
CHICAGO, ILLS.

THREE INCH TO FORTY-TWO INCH INCLUSIVE

Manufacturing Specialists
in
Sewer Pipe and Drain Tile
Equipment

The Stevenson Company

General Office and Works
WELLSVILLE, OHIO

Bulletins on request

Western Sales & Engr. Office
Monadnock Building
CHICAGO, ILLS.

J. C. STEELE & SONS, Statesville, No. Carolina

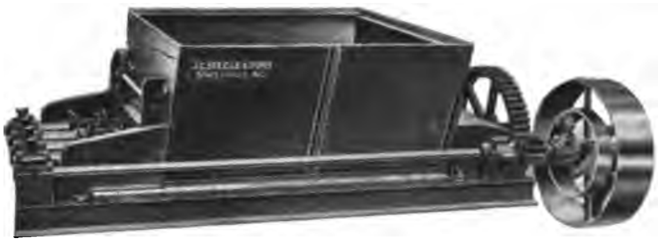
Western Representative: Geo. H. Smith, 3309 E. 37th Street, Kansas City, Missouri
Northern Representative: The Manufacturers Equipment Co., Dayton, Ohio

PRODUCTS:

- Side Cutters
- Brick Machines
- Dump Cars
- Disintegrators
- Feeders
- Hoists
- End Cutters
- Lift Cars
- Crushers
- Hollow Ware Machines
- Pug Mills
- Dry Pans, Etc.

THE STEELE EVEN FEEDER

This is a simple, strong machine, runs very slowly, and with but little wear.



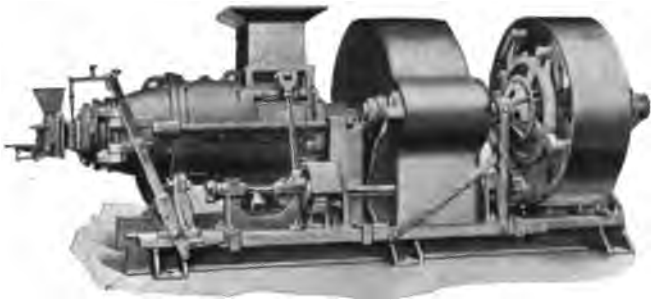
The shafts are driven by heavy spur gears, running in oil and enclosed. Furnished with friction clutch pulley, which can be fitted to either end. It has four shafts of 3-in. steel, over which are fitted chilled spiral knives. This gives width sufficient to prevent clay from bridging over.

No. 6 BRICK MACHINE. (We Build Six Sizes)

Capacity 50,000 to 150,000 brick per day.

Has only two gears and four bearings—a reduction of three bearings, two gears and one shaft as compared with most machines of large size. Bearings and gears very large, thus reducing strains and upkeep cost.

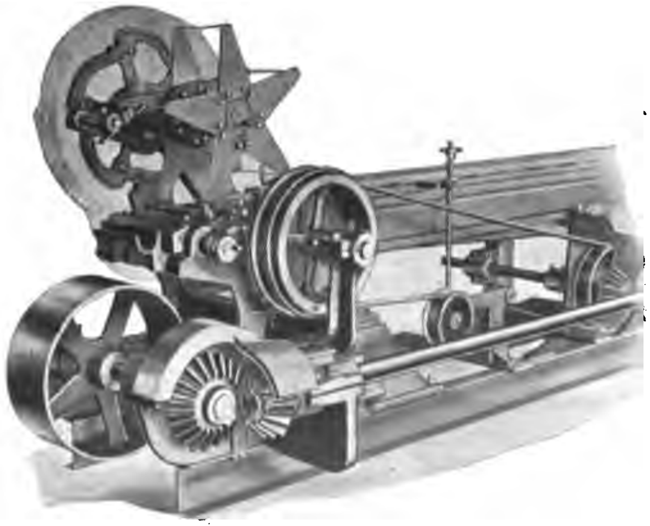
Gears are cut, pinion steel. Housed and run in oil bath. Cut shows taper front end cut. Sidecut is straight barrel.



Machine can be taken apart without elevating any part; will run equally well in either direction. Sills are of heavy "I" beams, with heavy channel for side strains. A thoroughly efficient and practical machine.

AUTOMATIC END CUTTER

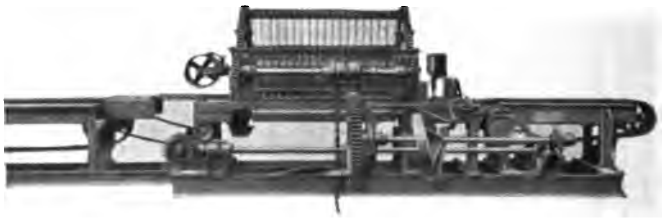
Cuts on edge, making one perfect face, dispensing with edger.



The Automatic End Cutter is used almost universally wherever end cut brick are made. This cutter can be attached to any auger brick machine. In principle, it is a continuously revolving reel, driven direct from the measuring pulley by irregular gears, made in such shape as to cause the wires to cut the column of clay off square. Due to the auxiliary or friction belt furnished with the machine, the softest and tenderest clays can be cut without swelling or breaking the column. New wires are very easily attached when the old ones become worn.

AUTOMATIC SIDE CUTTER

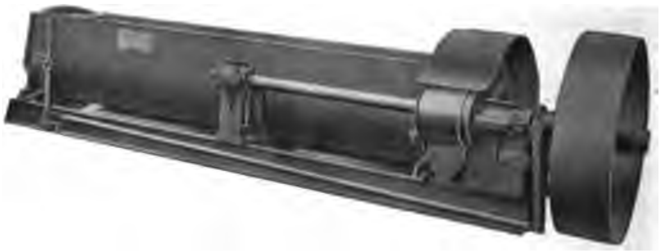
This cutter has a capacity of 15,000 brick per hour. It is built of high quality material, and first class workmanship, and its movements being simple and easy, insure long life.



Power is applied through crank motion, which eliminates all shocks and jars caused by sudden starting and stopping. Cuts straight. No swelling.

PUG MILL. (Four Sizes)

Capacity 1500 to 15,000 brick per hour.



The No. 5A Pug Mill, 12-ft. barrel, 30-in. diameter, 6-in. steel shaft, adjustable steel knives.

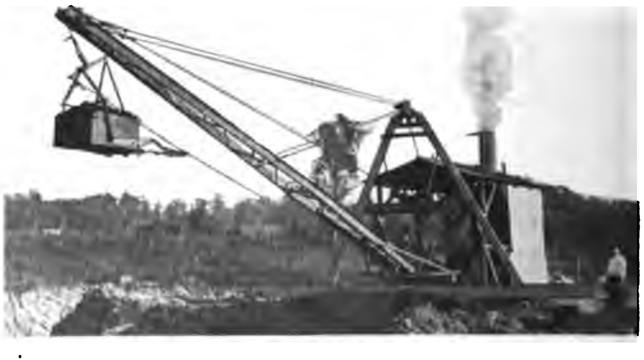
The No. 4A Pug Mill, 10-ft. barrel, 27-in. diameter, 6-in. steel shaft, adjustable steel knives.

The No. 3A Pug Mill, 8-ft. barrel, 24-in. diameter.

The No. 2 Pug Mill, 7-ft. barrel, 18-in. diameter.

DRAGLINE EXCAVATOR

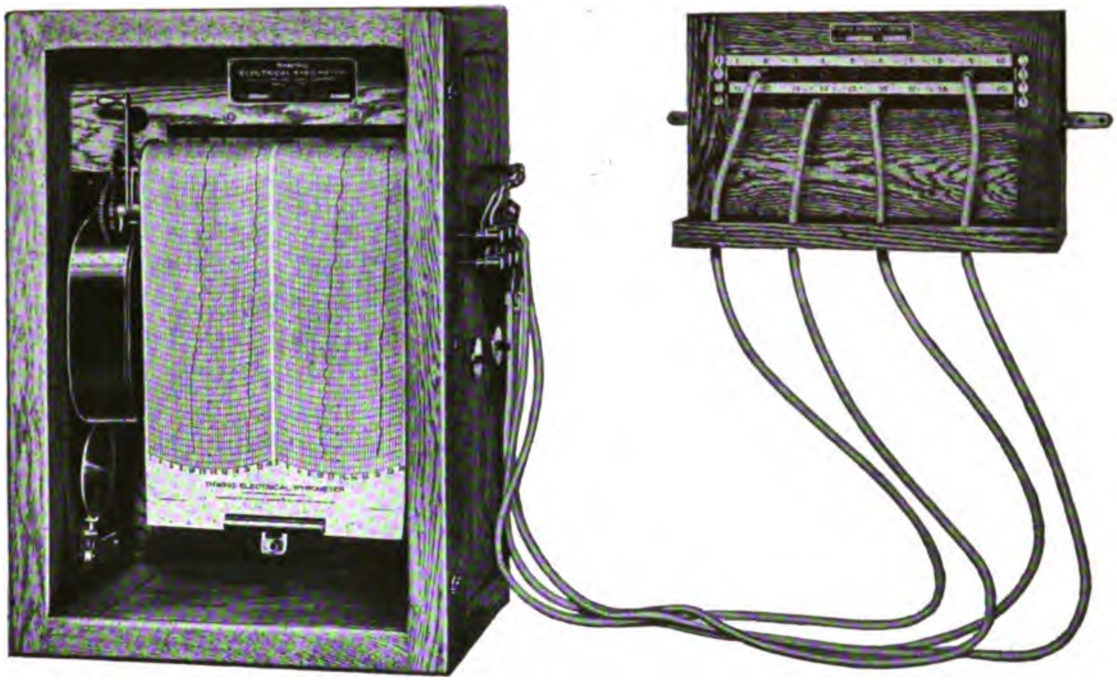
This machine is adapted for digging clay and loading into cars in the pit. Especially adapted to wet clay holes where water backs up, for obvious reason that both machine and cars may be always kept on top of ground above pit surface level. This machine is made in ⅝-yard and 1-yard sizes. It is not a new and untried machine. It is a very economical machine to operate as it requires only one man to operate.



Extremely substantial and reliable. Excavates spaces of from 60 to 75 feet wide at each setting, and is easily moved about. Makes clay digging easy.

THWING INSTRUMENT COMPANY

3363 Lancaster Avenue : : : : : : PHILADELPHIA, PA.



Most clay ware enters the kiln in good condition, but it does not all come out equally good.

A good recording Pyrometer will help a lot to improve the quality.

The first Thwing Pyrometer was built for a brick plant seventeen years ago and it was a success.

We are still specializing in this field and giving good service.

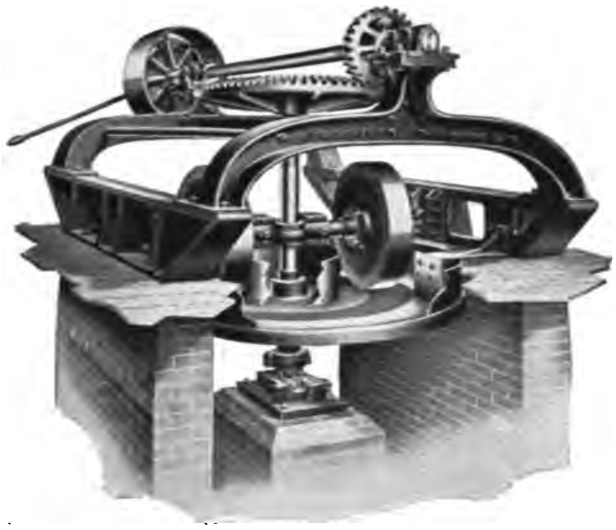
A customer recently reported that he had burned a kiln of 100,000 brick which came out all salable brick.

In almost every case the Pyrometer effects a saving in fuel by shortening the burning period. A saving of twenty to twenty-five per cent. is often reported. A strong feature of the Thwing System is the multiple recorder. A single recorder makes a clear ink record of four kilns at one time.

Another Thwing specialty is the Extra Heavy, High Duty, base metal Thermocouple, which effects large savings in first cost and upkeep. We, of course, supply platinum couples in the few cases where temperatures go too high for base metal.

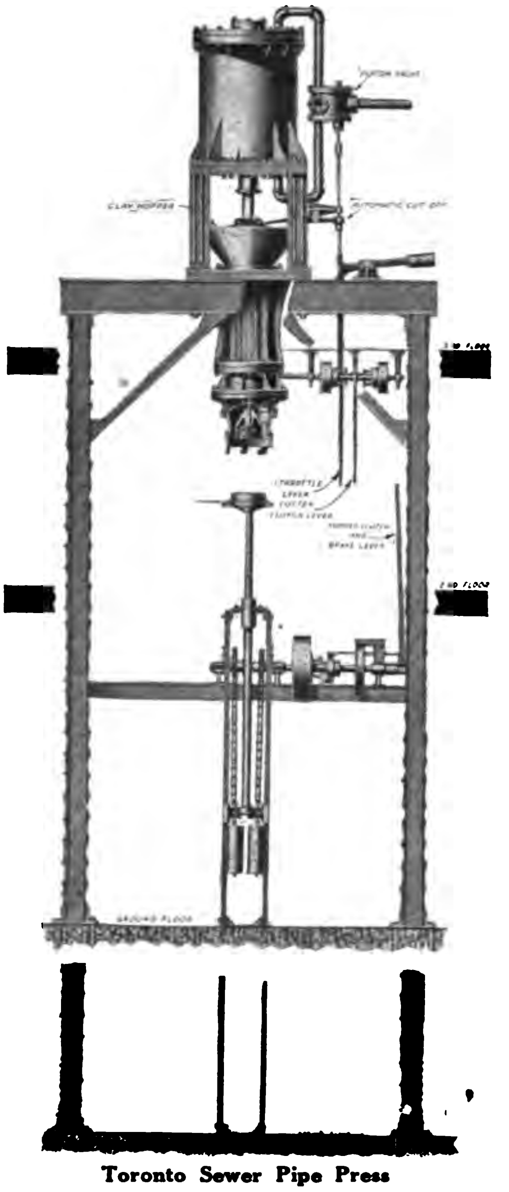
Dr. Thwing will gladly give the benefit of his long experience in the clay line to anyone in doubt as to what Pyrometer Equipment is most suitable.

THE TORONTO
MACHINE
TORONTO,



Type "E" 8 and 9 ft. Wet Pan

Toronto Type E Wet Pan is made in two sizes, 8 ft. and 9 ft. It is so designed that it may be used as a single unit or where two pans are needed as a double or duplex unit. When used in duplex installation the pans are placed so as to discharge into the same elevator. By this arrangement only one man is required to operate both machines. With each machine we furnish a pan plow or emptying device which will completely empty the pan in less than one minute's time. Write for Bulletin W-1.



Toronto Sewer Pipe Press

The Toronto Press: The single piston rod construction with four-leg cylinder support, open front and back with liberal distance between Steam and Clay Cylinder are original with this press and make it most accessible and practical.

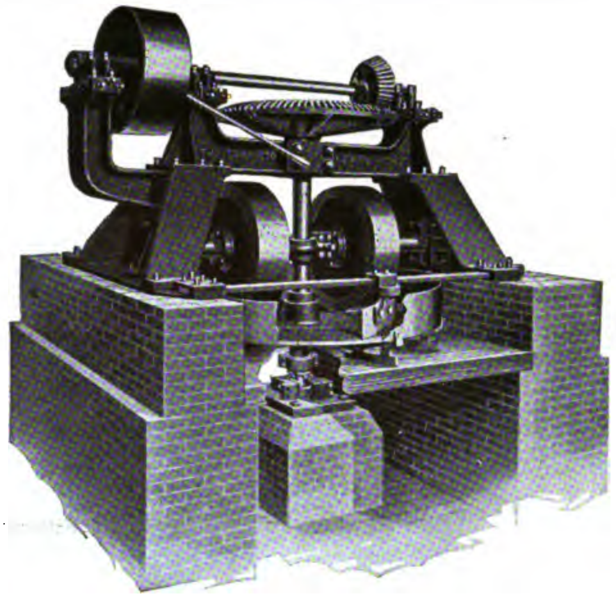
The space available in our presses permits us to install a Clay Hopper of larger capacity than in other types. This, together with improved Piston Valve, Automatic Cut-Off, large Steam Lines and the operation of Former and Brake by a single lever, have made our Presses the most rapid and efficient. They are built in three sizes; namely, 40-in., 44-in., 46-in. diameter cylinders having 18-in., 20-in., or 22-in. diameter clay cylinders and 54-in. actual working stroke. Write for Bulletin P-1.

We Manufactur

CLAY PLAN

Sewer Pipe Dies, Drain Tile Dies, B
Conveyors, Clay Augers, and Dr

FOUNDRY &
COMPANY
OHIO



Type "B" 9 and 10 ft. Dry Pan

Toronto Type B 9 ft. and 10 ft. Dry Pan: Designed to meet the requirements of those clay products manufacturers who want a machine with the housing extended down to the floor line. It has been demonstrated that a pan with the yoke construction for supporting the Mullers will grind more clay than a pan of any other construction. We believe this machine is without an equal. Made in both 9 ft. and 10 ft. sizes. Write for Bulletin D-2.

The Invincible Sewer Pipe Truck.
This truck is the result of our effort to furnish a one-man truck for the handling of heavy sewer pipe from the Press to the drying floor. That we have succeeded is evidenced by the use of these in numbers of plants. Truck is adjustable, one bolt loosened permits the change, same being accomplished in two minutes. Write for Bulletin T-1.

Invincible Sewer Pipe Truck

The Toronto Pug Mills are built with either single or double geared drive and in any length from 10 ft.-40 in. to 14 ft.-40 in. Pugging Tub is made from one steel sheet. Main shaft is forged steel and is hex shaped to receive the knife hubs. This machine is built to stand severe service. Write for Descriptive matter.

Toronto Pug Mill

omplete Line of

ACHINERY

es, Trucks, Clay Cars, Barrows, Elevators,
Hoisting Drums, Car Wheels

Mechanical Rubber Goods

for the

Brick and Clay Industry

THE salesmen and practical factory men of the United States Rubber Company are ready to assist brick and clay plant operators by advising as to the best application of mechanical rubber goods in order that the greatest possible service may be obtained for every dollar invested.

Take advantage of this Company's facilities and experience when in the market for mechanical rubber goods.

Through our nearest Branch you can obtain the fullest co-operation of our organization.

United States Rubber Company

BRANCHES IN EVERY INDUSTRIAL CENTER

THE WEBSTER MFG. COMPANY

Elevating, Conveying and Power Transmitting Machinery

4500-4560 CORTLAND STREET, CHICAGO

Factories: Chicago, Illinois, Tiffin, Ohio and Michigan City, Indiana

BRANCHES: BUFFALO CINCINNATI CLEVELAND COLUMBUS NEW YORK PHILADELPHIA SALT LAKE CITY

PRODUCTS:

Elevating and Conveying Machinery for handling all kinds of material, including coal and ash handling equipment, power transmitting machinery, malleable iron and steel chain, coal crushers, etc.

ELEVATORS:

Bucket Elevators of all types for bulk material, Continuous and Centrifugal discharge elevators with either steel or malleable iron buckets. V bucket combination elevator-conveyor for coal handling. Equipment made up in numerous ways, to meet the requirements of individual installations.

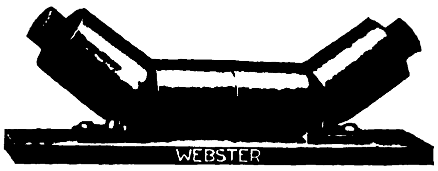
Continuous Bucket Elevator

Elevator Buckets

Centrifugal Discharge Elevator

CONVEYORS:

Everything in the conveyor line: Belt, Screw, Flight, Apron, Slat, V Bucket, Pivoted Bucket Carrier. A type of conveyor for every situation and for handling every sort of material. Especially Perkins Pivoted Bucket Carrier, the recognized standard of modern methods for handling coal in, and ashes out of the power plant, also for uses including the handling of hot clinkers in cement manufacturing.



Belt Conveyor

Perkins Pivoted Bucket Carrier

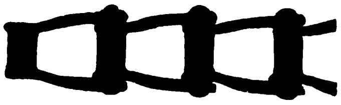
Screw Conveyors

POWER TRANSMITTING MACHINERY:

A complete line of shafting equipment for the most economical transmission of power by mechanical means: Friction Clutches, Gears, Pulleys, Sprockets, Bearings, etc.

CHAIN BELTING:

All types and sizes of chain for all purposes carefully made, thoroughly inspected, and rigidly tested in the most modern and best equipped of chain factories.



Chain Belting

COAL CRUSHERS:

Single Roll Crusher

In single and double roll types in varied sizes and range of capacities to suit. Will crush run of mine and lump coal to any required size.

ENGINEERING SERVICE:

We maintain a staff of engineers who have had years of successful experience in designing equipment for the handling of clay, cement, sand, gravel, coal, stone, etc.

Also in the Definition Section Refer to:
20, 44, 77, 98, 138, 140, 149, 150, 151, 152, 153, 154, 158, 163, 167, 171, 172, 243, 301, 317, 494, 554, 564, 599.

WELLER

CONVEYING and POWER TRANSMITTING MACHINERY

Will handle the materials inside or outside of the plant in the most economical manner. It will not only speed up the work but will save man power, thereby enabling you to increase production and meet competition.

Belt Conveyors

Weller Machinery is built and designed from knowledge accumulated by long experience. We have studied the needs of the clay worker and offer you service and equipment which will do the work at the least expense.

Rope Drives

WELLER MACHINERY

is an investment that will pay big dividends by increasing the output and reducing the operating costs.

WE DESIGN AND MAKE—

- Apron Conveyors
- Belt Conveyors
- Drag Conveyors
- Chain Conveyors
- Spiral Conveyors
- Bucket Elevators
- Elevator Buckets
- Portable Elevators
- Apron Feeders
- Reciprocating Feeders
- Coal Crushers
- Steel Hoppers
- Steel Storage Bins
- Bin Gates
- Car Pullers
- Power Shovels
- Screens
- Steel Chain
- Combination Chain
- Sprockets, Gears
- Friction Clutches
- Pulleys
- Bearings
- Hangers

Coal and Ash Handling Equipment

Screens
Rotary and Shaking

TELL US THE EQUIPMENT YOU ARE INTERESTED IN—CATALOGUE WILL BE SENT

WELLER MANUFACTURING CO.

1820-1856 N. Kostner Avenue
CHICAGO, ILL.

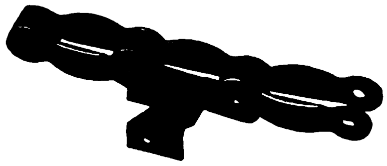
SALES OFFICES:

New York Boston Baltimore Cleveland Pittsburgh Detroit San Francisco Salt Lake City

The uses of the equipment we manufacture are described under items numbered:

20	38	39	42	44	45	46
47	48	49	50	77	86	94
95	96	98	100	101	114	115
116	138	140	149	150	151	152
153	154	155	157	158	167	171
172	211	212	213	214	224	242
243	245	256	301	302	335	369
438	494	500	501	530	531	532
533	553	554	555	556	617	626

WELLER • MADE • CHICAGO



Weller made Steel Chain.
Combination Steel and Malleable Chain.
Malleable Chain—Chain Drives, Sprockets.
Send for Chain Catalogue.

Geo. D. Whitcomb Company

Rochelle, Illinois, U. S. A.

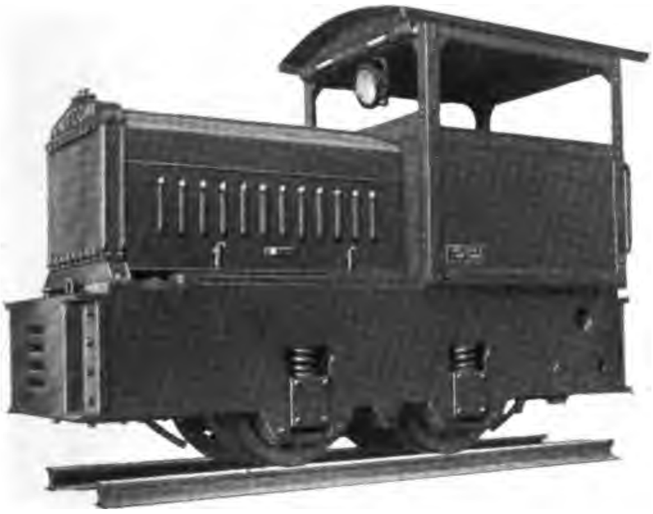
We manufacture Locomotives in various types, including Gasoline, Storage Battery and Trolley, in sizes of from 2½ tons to 25 tons. We make a specialty of Locomotives designed and equipped for quarries and brickyards.

The Whitcomb Six-Ton Positive Gear Locomotive

This design locomotive has, because of its efficiency and practicability, become within the past two years, the last word in industrial locomotives. No pains have been spared to make this locomotive the best of its size on the market.

Engine

The power plant of the Whitcomb Six-Ton is a type "EU" Waukesha Motor. Cylinder size—5x6¼ in. All parts oiled by a forced feed system, operating under a thirty-pound pressure. The cylinders are of the removable head design, bored and ground. Cooling system handled by a centrifugal pump of rugged design and is so arranged that the entire system may be drained from one point. Valves are of special alloy, split washer, taper type, with flat case hardened end.

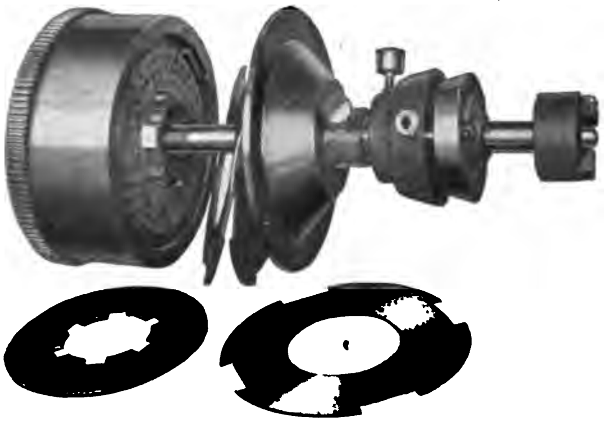


Ignition

Standard Equipment includes the aero Dixie Magneto, equipped with an adjustable coupling and impulse starter coupling and impulse starter. This equipment enables ease of cranking, the impulse starter turning the magneto armature shaft forward when the engine is passing center and producing a hot spark equivalent to the full running motor. A starting motor, generator, and storage battery can be applied at a slight additional cost.

Clutch

Made entirely in our factory, is of excessive capacity and of very latest design. The construction is alternate discs of saw steel and aluminum, the latter filled with cork inserts. Saw steel plates are driven by lugs on the flywheel, which houses the entire mechanism. The aluminum discs are carried on and drive a splined spider which is a part of the entire clutch. Pressure of discs is maintained by a heavy coil spring which acts directly against a thrust plate. Clutch is supplied with an improved spinning brake which works automatically as soon as the clutch is released. Clutch runs in oil, thus insuring long life.



Transmission

Selective gear type. Three speeds in each direction. All parts are interchangeable.

Radiator

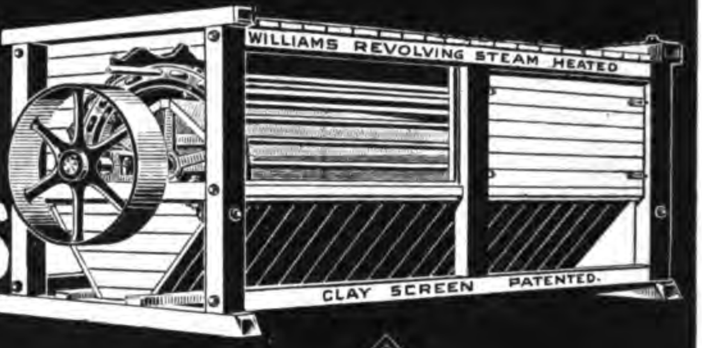
Artillery type. Shell is of cast iron, to which are bolted the cooling cores or sections. This type radiator permits repairing by replacing with new sections or applying blind gaskets in place of damaged sections, the only tool being needed is a monkey wrench. The radiator is sufficient for the most adverse conditions.

Axles and Wheels

Axles are made of forged steel carefully machined, and carried on heavy duty ball bearings. The wheels are rolled steel. Cast centers with steel tire can be furnished at additional cost.

Ask for our latest catalog. It contains complete details.

Williams
Patented
Clay Grinders



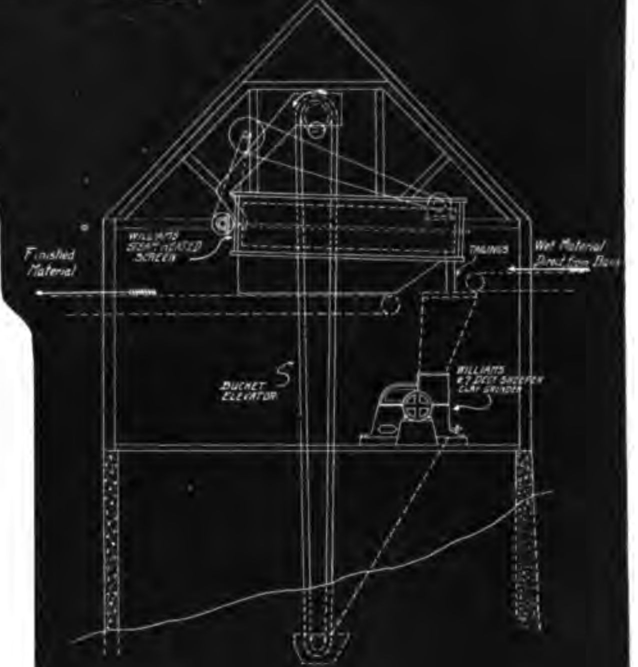
End Lime Pebble Troubles
Handle Wet Material Direct from Bank

Difficulties arising from lime pebbles and granular clays are economically overcome with Williams Deck Sweeper Clay Grinders and Steam Heated Screens.

They pulverize the lime pebbles along with the clay or shale to 8 mesh and finer, practically eliminating traces of lime, and make possible the production of a high-grade and homogeneous burned ware.

Wet clay and shale can be fed to the Williams direct from the bank even in rainy weather without danger of choking. All parts coming in contact with the clay are steam heated to prevent sticking of wet material. The Williams will pulverize clay so heavy with moisture that it will not stand in a column in a pug mill.

The sketch to the right shows the arrangement of one of two units at the Colburn Brick & Tile Company plant, Zumbrota, Minn., each capable of handling 200 tons per day.

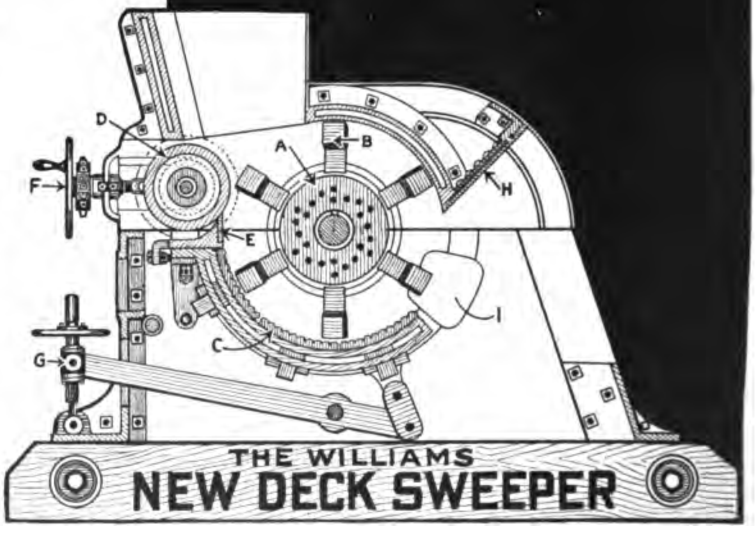

Finished Material
WILLIAMS STEAM HEATED SCREEN
TAILINGS
Wet Material Direct from Bank
BUCKET ELEVATOR
WILLIAMS #7 DECK SWEEPER CLAY GRINDER

Over 300 Types and Sizes of Williams Crushers and Grinders

Grind Dry Pan Tailings.
Crush old brick and tile.
Break down and grind hard shale.
Grind wet fire clay.
Crush coal.
Reduce sand rock to natural grain.

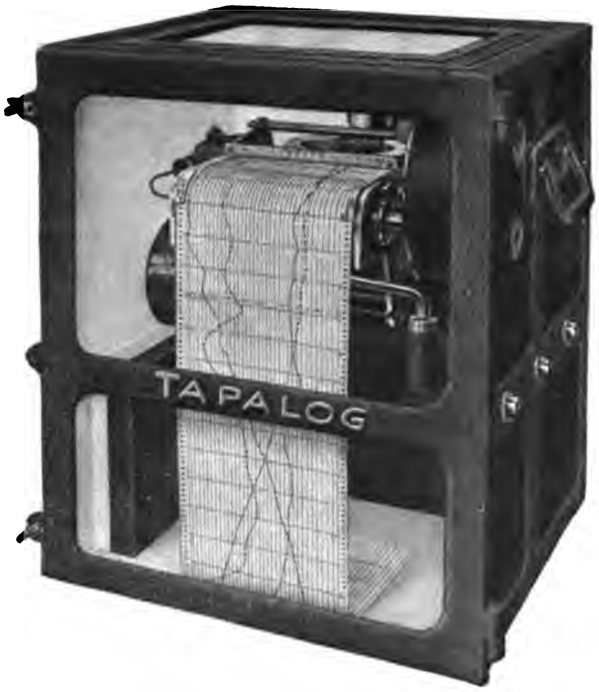
Summed up, the installation of Williams crushing or grinding equipment is your surest guarantee of success. Lay your problems before our engineering department; they will be glad to give you their recommendations.

Williams Patent Crusher & Pulverizer Co.
801 Montgomery St. ST. LOUIS, MO.
CHICAGO 37 W. Van Buren St.
NEW YORK 15 Park Row
SAN FRANCISCO 67 Second St.



Williams
Patent Crushers – Grinders – Shredders

THE WILLIAMS PATENT CRUSHER & PULVERIZER CO. ST. LOUIS, MO. U.S.A. TRADE MARK

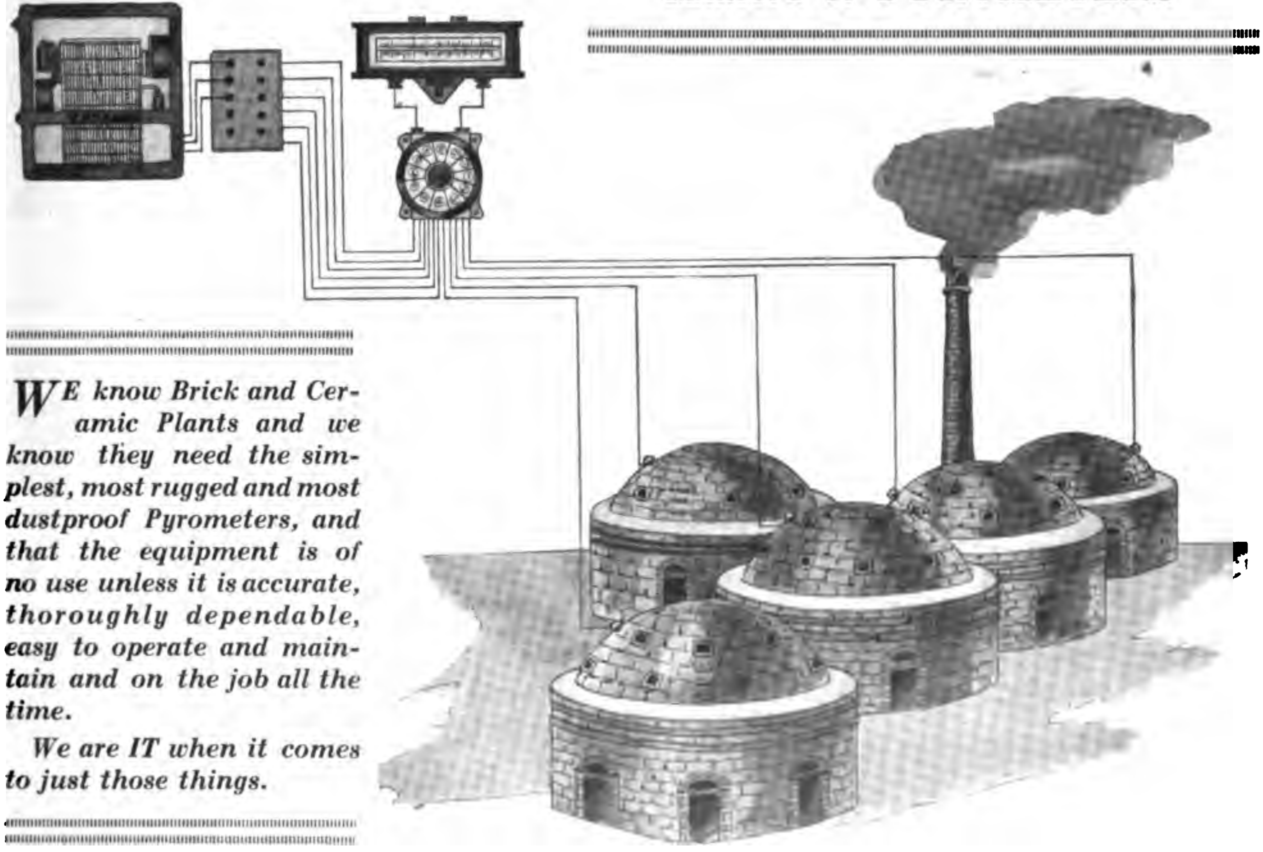


WILSON-MAEULEN CO.

St. Mary's Street and Concord Avenue

NEW YORK

Makers of PYROMETERS



WE know Brick and Ceramic Plants and we know they need the simplest, most rugged and most dustproof Pyrometers, and that the equipment is of no use unless it is accurate, thoroughly dependable, easy to operate and maintain and on the job all the time.

We are IT when it comes to just those things.

Brick and Clay Record

407 SOUTH DEARBORN STREET, CHICAGO, ILLINOIS

Member of the Associated Business Papers and Audit Bureau of Circulations

The Leading Clay Journal of the World

OUR PAST RECORD

For thirty years BRICK & CLAY RECORD has worked without pause, for the best interests of the clay products industry, always giving undivided support to every sanely progressive movement launched for its benefit.

Each issue has so substantially proven its ability to serve that it has long since acquired the distinction of being the one recognized authority in its field—THE LEADING CLAY JOURNAL OF THE WORLD.

NOW—after thirty years of leadership, its editorial activity and influence extend into every ramification of these great industries, and its circulation—WON BY ITS ABILITY TO SERVE—covers 90 per cent. of the entire number of clay plants in the United States with a considerable Canadian and foreign circulation—in addition.

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